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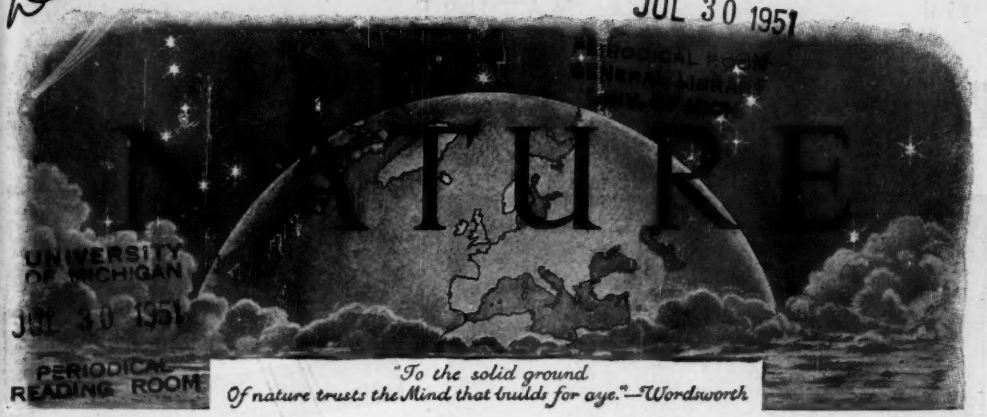

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PLANNING AND LAND UTILIZATION

THE progress report by the Ministry of Local Government and Planning* on the work of the Ministry of Town and Country Planning from its establishment in February 1943 until it was merged in the Ministry of Local Government and Planning in January 1951 touches on numerous matters of direct interest to the scientific worker. There is a most readable account of the way in which the establishment of the Ministry arose out of the unsuccessful attempts in the previous twenty years to deal with planning problems permissively and piecemeal, and out of the consistent recommendations of the Barlow, the Uthwatt and the Scott Reports in favour of a central planning authority. The legislation of these eight years, during which five major Acts were passed, is then reviewed, and, in particular, the difficulties of the Town and Country Planning Act, 1947, are explained, and the present organization for planning is outlined; the second part of the report deals broadly with local and regional planning and is at pains to show how development control operates, the position in regard to compensation and the reasons why progress in some respects has been so slight.

This lucid exposition of the work and policy of the Ministry explains many of its actions if it does not always justify them; but the major effect of such a stock-taking is to raise more fundamental issues, and on the chief of these the report is silent. It refers, for example, to difficulties which the local authorities encountered and stresses their new powers and responsibilities; but it ignores the important factors which are eroding the whole structure and spirit of local government and which were emphasized in a recent debate in the House of Lords on April 25. Although the report admits that town planning has few positive achievements to its credit as yet, the Ministry still appears to be confident that such achievements will be possible in the future. But the question whether the capacities of the Ministry really match its powers is never faced. Indeed, this survey leaves the answer to that question in some doubt. Many of the factors that have held up progress have been due to causes outside the control of the Ministry; but on the evidence of this report, the Ministry has sometimes failed to appreciate the meaning of effective priority. Moreover, when achievement is small, the question is inevitably asked whether the large machinery set up and engaged in the routine administration of planning controls is yielding a social dividend. If it is not doing so, and is not seen to be doing so, a clear answer must be forthcoming to the question what the public is getting in exchange for its money and for the disturbance which the planning authorities, and with them the Central Land Board, are causing.

Further, the really fundamental issues raised in the third part of the report, which deals with plan-

* Town and Country Planning 1943–1951. Progress Report by the Minister of Local Government and Planning on the Work of the Ministry of Town and Country Planning. (Cmd. 8204.) Pp. vii+215. (London: H.M. Stationery Office, 1951.) 5s. net.

ning problems of national importance, are not adequately discussed. Technical problems intrude to a limited extent into the discussion of local and regional problems in the second part of the report; but in the main it is with this third part that scientific workers will be most closely concerned.

First among these problems is that of the conflicting claims on land. Here again the report gives a reasonable account of the way in which the attempt is made to discharge the most important and difficult responsibility of the planner: that of balancing, and, where possible, reconciling, the rival demands between agriculture and other forms of development so as to secure that land is used in the best interests of the community at large. There is, it is emphasized, little more than half an acre of food-producing land in Great Britain for each member of the population, and the amount of improved farm-land also represents roughly the amount of land which, being well-drained and fairly level, is most suitable for development.

The report points out that it is a healthy sign of a more realistic attitude to agriculture that inroads upon agricultural land to-day provoke outspoken criticism; and on the showing of this report the Ministry has been more successful than is frequently supposed in resisting claims that conflict with the wider national interest. Particularly in dealing with the demands of the Services, the Ministry has been able to secure the withdrawal of a large number of important proposals. The record of its activities given in this chapter of the report deserves to be widely known; for it presents the broadest picture of the whole situation that is conveniently available. The question of mineral extraction and the restoration of land is dealt with in a subsequent chapter; but otherwise the picture is fairly complete. Industrial development, agriculture, transport, the hydro-electric schemes, water supply, housing, schools and playing fields—the demands which all these make for land are passed in review, and generally speaking it would appear that the situation is much more satisfactory than might have been expected in view of the failure to implement certain of the recommendations of the planning reports mentioned earlier.

Certain main features in the present situation are well indicated; but not all of them receive full attention. Stress is rightly laid on the importance of new proposals, such as hydro-electric schemes, being discussed with the local planning authorities while it is still possible to modify them. Nothing, however, is said as to the importance of such projects being considered—and at an early stage—in relation not merely to conflicting claims on the land but also to other schemes in the same field. Particularly in regard to the Services claims for land, some of the hydro-electric schemes and the projects for water-supply, there is reason for doubting whether the possibilities in regard to co-operation or alternatives have been properly explored or even considered before advancing some of the proposals. Few if any of the water undertakings have faced the plain fact that unless steps are taken to deal with the waste of water, all the possible gathering grounds of Britain will be insufficient to meet the demand within a few decades, even if agriculture and every other interest are entirely disregarded.

Nor is there anything in this report which brings out adequately the Ministry's anomalous position. Where the demands for land come from other government departments, it is one among others in attempting to adjudicate, and may even be placed in the invidious position of attempting to judge its own case. The predilection of the Service departments and other departments to do this is one cause of the bitterness with which their claims for land are received and discussed, and the Ministry should not be placed in such a position. It might, indeed, reasonably be reponsible for attempting to secure agreement between departments in the light of government policy for the particular region concerned or the country as a whole, and it might even be responsible for seeing that the national point of view is adequately presented to the interdepartmental committee which is called upon to resolve any continuing clash of opinion. It cannot fairly be responsible for decision.

Although the existing arrangement has worked somewhat better than might have been expected, there have been some unwelcome reminders of late that the situation is not without its dangers. One case, not mentioned in this report, is the new afforestation plan of the Forestry Commission for the Quantocks, reasoned objections to which, on scientific grounds as well as on those of amenity, have been advanced by a local society, the Friends of Quantock. The area is also one which was expected soon to become a detached part of the Exmoor National Park. A War Office scheme for a training area for Territorials at Upper Hulme, between Leek and Buxton, also conflicts with the purpose of the Peak District National Park, and threatens a breeding ground of rare birds; while at the other side of the same National Park a tentative proposal for a reservoir threatens the whole Edale valley.

A fresh threat to Braunton Burrows has also been raised by the War Office application to use this area for training in combined operations (see *Nature*, June 2, p. 869). The scientific importance of this area was indicated in a note in *Nature* so long ago as November 30, 1946; that the area should again be in dispute testifies to the unsatisfactory character of the present arrangements for dealing with such claims, and to that weakness in the Ministry of Local Government and Planning which the present survey tends to ignore. The Ministry's main function in interdepartmental discussions is to see that due weight is given to all conflicting factors, and, until the Nature Conservancy was established, the Ministry was spokesman for the interests over which the Conservancy now watches. It remains to be seen whether such scientific interests will be more effectively pressed by the Conservancy.

When all credit is given to the Ministry for its success in the field generally, on the evidence of this report alone some much more effective means is required for dealing with the claims of government departments, notably where the Services or mineral workings are concerned, and for ensuring that there

is proper consideration within departments before the discussion reaches interdepartmental level at all. There is no evidence that the Minister of Defence has attempted to secure co-ordination of the demands of the three Services for land for training purposes or proper co-operation in the use of the land allocated to them; a similar situation appears to exist in regard to mineral working. This question is discussed in some detail in the next chapter of the report. Here again little objection is possible to what is postulated as the main objectives in any policy which is to reconcile industry's need for raw materials with other claims on land, or even to the steps which are regarded as necessary to implement that policy. It is essential to see that mineral working, while meeting industrial needs adequately, does not waste land, interfere with agriculture or damage amenity, and that it is properly integrated with building and other necessary surface uses. That involves, in turn, keeping important mineral deposits available for extraction by preventing surface development that might unnecessarily sterilize them, and also ensuring that suitable deposits are available to mineral undertakers in accordance with the national need.

The doubts that arise in this matter are rather as to whether the steps already taken are sufficient to achieve the desired results, particularly since the provisions of the Mineral Workings Bill for the restoration of land devastated by mineral workings apply only to specified counties and to opencast workings. This exclusion of other mining appears to be unsound; and although according to this survey the Ministry of Fuel and Power consults the Ministry of Local Government and Planning before sites are requisitioned, there is no assurance that this practice will continue or that there is any effective means at present of restraining the Ministry of Fuel and Power from judging its own cause.

Despite, therefore, the examples of successful representations quoted in this report, we cannot rest content with the steps already taken. It is not sufficient for all mineral workings to be brought completely under planning control, and for the Government to take its appropriate place in the planning of mineral workings. It will be little better placed than local authorities to relate particular questions to long-term needs unless it possesses far wider knowledge of both the geological and the industrial aspects of mineral production. Basic information on the economics of production and distribution and of the detailed requirements were lacking, as well as facts about the distribution within known deposits of economically valuable material and its physical and chemical qualities, when mineral extraction first came under effective planning control.

Research into these problems is the first essential, and should be undertaken as a matter of urgency. The absence of the basic information makes nonsense of the suggestion in this report that the responsibility of deciding that certain areas shall not be worked for minerals must carry with it the obligation to ensure that suitable areas are selected for working, and that industry can secure the necessary ownership or working rights. Had the essential information on the economics of working, including restoration, and on alternative sources been available, some of the worst devastation due to opencast coal mining might have been avoided. No lesson of this survey is indeed more emphatic than that of the futility of attempting planning in any positive sense except on the basis of factual knowledge.

Something more is said on this point in the final chapter of the report. Although the research staff of the Ministry of Local Government and Planning includes geologists who are responsible for preparing reports on the minerals essential to industry and on the incidence of the more common minerals won by surface working, it does not appear that expansion of this staff is either contemplated or desirable. The task of the Ministry should be rather to stimulate the necessary investigations by the bodies best equipped for the purpose, such as the Geological Survey, the Department of Scientific and Industrial Research, the universities and so on. The field is one in which an Economic Research Council might have been of invaluable assistance, particularly when co-operating with other bodies such as the Agricultural Research Council.

The activities of the Ministry in regard to the protection of amenity have already been mentioned incidentally; but a separate chapter of the report discusses such problems in general, and in particular relation to the preservation of trees and woodlands, as well as the preservation of buildings and the design and appearance of new buildings. Its responsibilities in regard to national parks are summarized in a chapter which adds little to what was contained in the first report of the National Parks Commission. The account, however, is even more persuasive as to the ability of the Ministry to restrain the departments and other interests from causing irreparable damage to our scenic heritage. Moreover, in confirming, substantially as it was made by the National Parks Commission, the designation order for the Peak District National Park, the Minister for Local Government and Planning not only strongly endorsed the views of the Commission, but also stressed the importance of mutual accommodation between those who live and work in the parks and those who visit them.

The importance of that factor is somewhat obscured in this report and indeed by the very vigour with which Mr. Dalton is implementing the provisions of the National Parks Act. It is all to the good that the establishment of national parks should proceed apace, and that a national park safeguarding the Pembrokeshire coast and the Prescelly Hills should be proposed for this year and one for Brecon Beacons and the Black Mountains next. But there is at least a danger that too much may depend on the interest and personality of the Minister himself, and under Mr. Dalton's successors the Ministry may prove unable to sustain the battle on the same equal terms. It is plain from this report that there is no one man or body equipped with all the factual knowledge on which to base sound decisions as to the right use of land, nor is it easy to visualize such a body when all the necessary fact-finding and

research have been completed. The most that can be expected is some means of preventing snap and *ex parte* decisions in which conflicting claims and long-term interests are ignored. Adjustment of such claims and of short- and long-term interests must of necessity take place at a high level, but this does not imply of necessity a super-planning authority. The Ministry of Local Government and Planning is clearly capable of bringing into the discussions the reasonableness which makes co-operation and adjustment possible, and to that extent has justified its establishment though not necessarily the full extent of its organization. On that side there is room for much clearer thinking; but on the record here presented, the Ministry is entitled to claim the support of all who are concerned to see that the use of the land of Britain shall be determined on the basis of the fullest possible factual knowledge and on the due consideration of all the conflicting interests involved from a national and not from a purely sectional point of view.

TIME AND CLIMATE

Dating the Past

An Introduction to Geochronology. By Prof. Frederick E. Zeuner. Second edition, revised and enlarged. Pp. xviii+474+24 plates. (London: Methuen and Co., Ltd., 1950.) 30*s*. net.

THIS work is a second edition of a book first published in 1945. It opens with a discussion of the methods of dating by tree rings and varves, and their use in establishing a chronology of Neolithic and post-Glacial times. This is followed by a discussion of the correlation and climatic changes of the Old Stone Age. The last eighty pages describe the time-scale for the whole geological column before the Pleistocene, as derived from radioactive considerations, and discuss the rate of evolution. The subject therefore includes diverse fields of the greatest difficulty and complexity. Its proper discussion demands a critical consideration of the whole of archæology and prehistory, a balanced judgment on the most delicate points of statistical theory and some knowledge of astronomy, meteorology and nuclear physics. To say that the author does not possess the necessary knowledge is not a criticism: no one does, least of all the present writer. To pick holes is easy; there are statements that "make one gasp and stretch one's eyes", as, for example, where it is said on page 16, "of 96 sun spots no fewer than 63 have periods between 9·9 and 11·9 years". Such absurdities are probably inevitable in so long and diverse an argument and do not touch the real purpose of the book.

The main theme is that the Croll–Ball–Milankovitch theory of the astronomical cause of ice ages gives an alternation of cool and warm periods that conforms to the facts of archæology. I must confess that I remain unconvinced. An enormous and intricate structure of fact and surmise is presented that at many points fits well with the calculated curves giving the variation of the heat arriving from the sun at the surface of the earth. It is rash for an amateur in these matters to question such a performance; but awkward doubts occur. Why is America dismissed in one page although, "In North America, Pleistocene chronology is, of course, highly developed"? Can it be because it gives little evidence in support of Milankovitch? Is the evidence for three phases of the last glaciation derived from the three buried channels near the mouth of the Thames convincing? There is a channel for each phase, and in a table it looks admirable until one remembers that there are dozens of other buried channels in southern England that are not mentioned.

It may with some justice be argued that a dubious or incorrect principle is better than none, and that, right or wrong, Prof. F. E. Zeuner does provide a framework on which to hang the facts, and does introduce some order into the chaos of prehistory. If the framework is, in fact, wrong, the quickest way to demonstrate it is to hang facts on it until they patently will not fit. In the meantime, it would be difficult to suggest an alternative as detailed that would fit at all.

I think it is impossible for anyone used to the firm ground of physical science, or even to the penumbra of doubt that usually accompanies a geological fact, to read any discussion of prehistoric chronology without a profound feeling of distrust. The mind revolts at such fare. Why should one believe Prof. A. rather than Prof. B. or Prof. Z.? What are the criteria? What is fact and what is wishful thinking? If one is told bluntly that Korn has observed a "sunspot cycle" of 11·5 years in the thickness of the varves in the pre-Cambrian Nama beds in South-West Africa, does it mean that the matter is beyond reasonable doubt? After looking at Korn's paper, I am very doubtful of the existence of any real periodicity, and certain that the point has not been established. The correlation of varve and tree-ring sections and the extraction of periodicities from them are statistical questions involving series the terms of which are not independent. It is remarkable that the great developments in the theory of such series in the last ten years have not been applied in this field. Arguments based on the assumption that the terms must either be independent or be governed by 'periods' can never be convincing. There seems to be a firmly planted instinct in the human mind that wishes to find periods in auto-correlated series, and there is no subject in which there is a greater danger of error. The weakness of Prof. Zeuner's argument in this respect is not to be laid at his door; the subject has just not been developed in a satisfactory manner. In some matters he shows more caution than his predecessors; in particular, he expresses a well-founded disbelief in the teleconnexion of varve series.

In spite of all these doubts and uncertainties, Prof. Zeuner's book does serve a most valuable purpose. It brings together in a coherent way a great body of knowledge and sets it out in such a manner that everyone can see how defective our understanding of it is. The next step in the solution of the difficulties probably lies with the physicist, the chemist and the oceanographer, and for them an easily digested summary such as this is invaluable. It is likely that in the next ten years work on radioactive carbon, on the distribution of isotopes and on ionium in ocean cores will enable us to obtain a knowledge of the changes of temperature in the past and of their dates. It may well be that in his next edition Prof. Zeuner will be able to give some of his dates and correlations as facts. He could then with confidence reverse many of his arguments and use the dates to support his interpretation of the facts. E. C. Bullard

MATHEMATICS OF NON-LINEAR VIBRATIONS

Nonlinear Vibrations in Mechanical and Electrical Systems

By J. J. Stoker. (Pure and Applied Mathematics, Vol. 2.) Pp. xix+273. (New York and London: Interscience Publishers, Inc., 1950.) 40*s*.

Contributions to the Theory of Nonlinear Oscillations

By S. P. Diliberto, L. L. Rauch, F. H. Brownell, M. L. Cartwright, J. G. Wendel, C. E. Langenhop, A. B. Farnell, W. Wasow. Edited by S. Lefschetz. (Annals of Mathematics Studies, No. 20.) Pp. ix+350. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1950.) 14*s*. 6*d*. net.

FOR more than two hundred years mathematicians have studied the properties of linear differential equations. In many problems, such as that of pendulum motion, where the equations are really non-linear, the linear approximations give a sufficiently good idea of what actually happens. However, engineers knew that many oscillatory mechanical devices had properties not explicable by the linear approximations; but until comparatively recently, these devices were small and inexpensive, and the easiest way to investigate them was by constructing and operating them. But now, in these days of aircraft, guided missiles and automatic chemical-process plants, it is an economic necessity to calculate in advance the possibly troublesome phenomena which may arise from the vibrations being non-linear. This work was at first undertaken chiefly by engineers and physicists. Now the pure mathematicians, especially in the United States and the U.S.S.R., have realized their opportunities in this field. They are pleasantly surprised to find how important the classical work of Poincaré, Hill and Mathieu turns out to be as a starting-point in attacking the new problems.

An excellent introduction to the subject is given by the first book, that by Prof. J. J. Stoker, whose lucid exposition gives continual references to particular mechanical or electrical systems from which arise the differential equations considered. The first chapter recalls the properties of linear vibrations. The second and third deal with free vibrations when the restoring force is non-linear, using a graphical discussion of the energy curve in the displacement–velocity plane, in which the time is taken as a parameter, and Poincaré's discussion of singular points is of fundamental importance. These methods, however, cannot be used when the time occurs explicitly in the differential equations, as for forced motion. The fourth chapter gives Duffing's apparently unnatural method for dealing with these problems, a method which succeeded when all straightforward approaches, even that of Rayleigh, had failed. This chapter includes also a number of useful analytical methods, in particular those of iteration and perturbation, and ends with a table showing some contrasts between linear and non-linear vibrations. The fifth chapter deals with non-linearity in the damping, which is responsible for 'self-sustained' oscillations, such as occur in radio valves, and in the 'flutter' of aircraft wings. The collapse of the Tacoma bridge is generally ascribed to these oscillations. A special analytical method for such problems was devised by Van der Pol, and this has been used extensively in the U.S.S.R. Other methods are due to Andronow and Witt, and to Miss Cartwright and Littlewood. It is rather surprising that the sixth chapter should deal with *linear* differential equations with periodic coefficients, but these are necessary for discussing the stability of non-linear oscillations. The classical results of Hill, Floquet and Mathieu thus gain a new importance. The appendixes give a rigorous mathematical justification of methods used in the main part of the book, which can be warmly recommended to engineers, physicists and mathematicians.

The second work under review is a collection of monographs edited by Prof. S. Lefschetz and will appeal chiefly to mathematicians engaged in research on the theoretical aspects of the subject, though many of the problems have a physical origin. S. P. Diliberto discusses some general questions connected with Poincaré's results; L. L. Rauch deals with a differential equation of the third order arising from a problem concerning radio valves; and F. H. Brownell investigates the oscillatory solutions of a difference-differential equation, such as arise in control problems. The longest paper is by Miss M. L. Cartwright, and deals with forced oscillations. Similar problems are treated in a different way in papers by J. G. Wendel, by C. E. Langenhop and A. B. Farnell, and by W. Wasow. This volume, like other Princeton University publications, deserves careful study by research workers.

H. T. H. PIAGGIO

MECHANICAL PROPERTIES OF METALS AT HIGH AND LOW TEMPERATURES

The Properties of Metallic Materials at Low Temperatures

By P. Litherland Teed. (Monographs on Metallic Materials, published under the authority of the Royal Aeronautical Society, Vol. 1.) Pp. viii+222. (London: Chapman and Hall, Ltd., 1950.) 21*s*. net.

Properties of Metals at Elevated Temperatures

By George V. Smith. (Metallurgy and Metallurgical Engineering Series.) Pp. x+401. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 59*s*. 6*d*.

THE wide temperature range, some 1,100 deg. C., over which the engineer is concerned with the mechanical properties of metals and alloys is covered by these two volumes.

"The Properties of Metallic Materials at Low Temperatures" is the first of a series of monographs to be published under the authority of the Royal Aeronautical Society, and contains a survey of existing knowledge regarding the non-ferrous metals and their alloys, and the steels. The bringing together of this information is justified not only in connexion with the construction of planes for high-altitude flight, but also by the increasing use of low temperatures by the chemical engineer. Chapters are devoted to a consideration of the major mechanical properties of aluminium, iron, magnesium, copper, nickel, zinc, tin and lead and their alloys, about one-half being devoted to the plain carbon and alloy steels. The author points out that the variations of properties at very low temperatures are as yet unpredictable, and makes the further most pertinent point that the fruits of long and careful work are too often wasted as a result of inadequate description of the composition, and the mechanical- and heat-treatment of the samples investigated.

The treatment in the second work, "Properties of Metals at Elevated Temperatures", differs considerably, in that almost half of the book is devoted to a more-or-less fundamental discussion of plastic deformation in general, both in single and polycrystalline material. A not inconsiderable proportion of this is concerned with room-temperature properties and behaviour, although the effects of higher temperatures do come in for consideration. This section provides an admirable introduction to the mechanical properties of metals, but appears, in places at any rate, to have no very direct connexion with the real subject of the book. Following this introduction is a chapter on high-temperature tests and the equipment employed, after which are discussed the effects of chemical composition on creep behaviour, of manufacturing variables, varying temperature and load, scaling and microstructural changes at high temperatures—the latter particularly dealing with the stainless steels—and a final chapter on design for service at elevated temperatures. A most useful series of nearly five hundred references to original work is given, and an appendix deals with "superalloys", that is, materials with the highest (as yet) available strength at elevated temperatures. A very great deal of work has gone into the preparation of this most useful account, which has the added advantage that it provides a satisfactory summary of work done throughout the world, and not only in the United States.

Both these volumes can be recommended to the attention of all metallurgists and engineers who are concerned with the mechanical behaviour of materials at temperatures either below or above the normal.

F. C. Thompson

ELECTRONIC DEVICES

Voltage Stabilizers

By F. A. Benson. Pp. 125. (London: Electronic Engineering, 1950.) 12*s*. 6*d*.

The Industrial Applications of Gasfilled Triodes (Thyratrons)

By R. C. Walker. Pp. xi+325. (London: Chapman and Hall, Ltd., 1950.) 40*s*. net.

THE use of electronic devices in instruments and machinery of all kinds is becoming ever more widespread, both in industry and in the laboratory. Such apparatus is often designed by those who have only a very general training in electronics, and there is thus a great need for monographs on specialized applications to which one can turn for a more detailed description than can be found in general text-books, all the more so since the published literature covers a wide range of scientific and technical journals. Such monographs fall naturally into two classes: those which describe the different types of circuits devised to perform similar functions, and those which describe the different applications of a given circuit element.

"Voltage Stabilizers", which is based on the author's recent series of articles in *Electronic Engineering*, falls into the first of these two classes. In addition to dealing with the conventional types of A.C. and D.C. stabilizing circuits embodying saturated-core transformers, glow tubes and hard-valve circuits, some of the newer and less orthodox non-linear circuit-elements are briefly treated. I found the chapter on glow-discharge tubes particularly valuable, since a large amount of data on the stability of different British and American tube-types is collected here.

"The Industrial Applications of Gasfilled Triodes" is the latest of Walker's monographs and deals with the many different applications, not only of thyratrons but also of other grid-controlled gas-filled tubes. Like the author's two previous volumes, it should prove useful in suggesting ways in which problems of automatic control and measurements can be solved. It is a pity that the relatively high price may keep this book away from many laboratory bookshelves.

An important feature of monographs is necessarily an extensive bibliography, and both books are well served in this respect, although in "Voltage Stabilizers" one would have appreciated a classification of the references given at the end of the book.

U. W. Arndt

PASTEUR

Louis Pasteur, Free Lance of Science

By René J. Dubos. Pp. vii+418. (London: Victor Gollancz, Ltd., 1951.) 18*s*. net.

DR. RENÉ DUBOS is already well known to scientific men as the author of two valuable books, namely, "The Bacterial Cell" and "Bacterial and Mycotic Infections in Man". He has now written a book which has a much wider appeal and will be enjoyed by all who are interested in biological science and its development. No new information about Pasteur or his work has recently come to light; but it is interesting to have a book about a great man of science written after a considerable period of time has elapsed since his death, so that his influence upon progress can be critically examined.

Dr. Dubos is a Frenchman who is engaged in bacteriological research, and is especially well fitted to write about Pasteur's life and work. There is a vitality and enthusiasm in the presentation which suggests that as he studied the information existing about Pasteur, he was caught by the brilliance and importance of Pasteur's achievements, and could not rest until he had set down the whole story as he saw it and as he thought it should be told. It is not a simple biography, for it deals with the historical background which made Pasteur's discoveries possible, and with the philosophical implications of Pasteur's pronouncements. It is the work of a critical man of science who wishes to appraise correctly the scientific value of a man's work, and to try to discover whether his successes were due to the times as much as to the man, and if more to the man, to what especial characteristics.

This approach has resulted in a very interesting book which will not only be appreciated by scientific men, but also by the growing number of individuals who are to-day interested in scientific discovery, in how it comes about, and how it affects the life of the community.

The broad outlines of Pasteur's life and work are probably known to many, and the use of words such as 'vaccines' and 'pasteurization' keeps him always in mind. The historical background of the times in which he worked, and the intensity of purpose, hard work and self-denial which he had to exercise in order to overcome the many difficulties and to achieve success, may well be forgotten. All is clearly set down, and the greatness of Pasteur is vividly brought home to the reader.

It is a book which can be read and re-read with enjoyment and profit.

Cytology and Cell Physiology

Edited by Geoffrey H. Bourne. Second edition. Pp. xvi+524. (Oxford: Clarendon Press; London: Oxford University Press, 1951.) 50*s*. net.

THE second edition of this important book is to be welcomed, even though nothing like a coherent view of protoplasmic activity can yet be obtained from it. It is also perhaps to be kept in mind that its effective date is not 1951 but more nearly July 1948, as indicated by the preface. Even so, a great deal has happened since before the Second World War (the effective date of the first edition was 1941). Somewhat ironically perhaps, the most buoyant expressions of optimism regarding imminent progress to be expected in the next decade have been reprinted without change in the least emended chapters. On the other hand, where opportunity has been found for incorporating a large body of new matter, the usefulness to the reader of the subjects discussed has been very greatly enhanced. This concerns especially Schulman's chapter on monolayers, White's on cytogenetics, Bourne's on mitochondria and Golgi bodies, Ludford's on pathology, and Blaschko and Sanders's revision of the chapter on intracellular enzymes.

Two new chapters on histogenesis in tissue culture and in evolution respectively, by Fell and by Willmer, introduce aspects of normal (as opposed to pathological) histology in animals. At the other end, two additional introductory sections by Sanders and Barer, respectively, deal with some of the very powerful new technical developments such as phase-contrast microscopy, electron microscopy and the reflecting microscope. A certain amount of repetition has resulted from such a considerable insertion of new matter, and there are also a few distressing misprints, such as the quotation of 1300 A. as a wave-length of the infra-red (p. 71). Some of the new references mentioned in the text are omitted from the bibliographies.

These are, however, minor defects. On balance, the changes have been very beneficial, and though no single reader is likely to be equally concerned with the whole contents of the book, the great variety of recent bibliographies collected together under one cover is probably one of its most valuable features.

The Littoral Fauna of Great Britain

A Handbook for Collectors. By Dr. N. B. Eales. Second edition. Pp. xvii+305+26 plates. (Cambridge: At the University Press, 1950.) 20*s*. net.

THE second edition of Dr. N. B. Eales's well-known student's book of sea-shore animals has four additional pages devoted to examples of practical exercises in quantitative distribution on sandy and on rocky beaches. These pages are inserted in the appendix, leaving the main pagination unchanged. Some useful descriptions of eggs and egg capsules have been added here and there, and there are other small additions. Thus, *Elminius modestus* appears in the section on cirripedes, and the magnesium chloride method of narcotization has been added to that on preservation. The price of the book has been substantially increased.

In compiling this book the author was faced with a task from which most would have shrunk. One cannot but admire the way in which she has collected and set out an immense amount of most useful information on the classification, external anatomy—and, to a small extent, ecology—of most common and many uncommon shore animals and provided keys to help with their identification. There is no doubt, too, that this unique compilation is well liked—and justly so—by students attending courses in marine biology, although it probably covers more adequately the fauna at Port Erin than elsewhere, in spite of the inclusion of many species not recorded for that locality. The problem of selection must have been one of great difficulty, and it is only to be expected that it is not as successful for some localities as for others. Some groups receive relatively full treatment (for example, decapods, molluscs, echinoderms and fishes), mention being made of almost all species likely to be found on British shores, and quite a few from the region immediately beyond. Other groups, however, are not so completely covered. The treatment of the polychætes, for example, is inadequate for the south-west of England and, at Plymouth, often leads astray students who ignore the author's own instruction to consult the appropriate monograph for final identification. The inclusion in a future edition of another twelve or eighteen common Plymouth shore polychætes would do much to put this right. The section on amphipods could also be enlarged with advantage.

D. P. WILSON

Flora of the Land of Israel

Iconography. By Naomi Feinbrun and Michael Zohary. Pp. 12+50 plates. (Jerusalem: *Palestine Journal of Botany*, Hebrew University, 1949.) n.p.

THIS is a series of line drawings from living specimens portraying quite effectively a selection of Palestinean plants, mostly on a life-size scale. In addition to the habit, botanical details for some of the species are also illustrated. The collection is a miscellaneous one, and indeed no less than twenty-seven families are represented on these fifty plates. There is no obvious basis of selection; but, since the authors refer to this as a first step towards an iconography of the local flora, one may anticipate that it is but an instalment of what is intended ultimately to be a complete series.

Several of the figures represent endemics of Palestine, including three species of *Iris*, namely, *I. atropurpurea*, *I. mariæ* and *I. nazarena*, the liliaceous *Bellevalia desertorum*, and *Orchis galilæus*. The brief accompanying notes furnish some morphological and other data, as well as indications of the distribution; but diagnostic botanical characters would have been a welcome addition, and the value of such would have been enhanced as the work proceeds and more species are added in the different groups.

The drawings mostly convey an excellent idea of the character of the species, and some, as, for example, those of the wild *Cyclamen persicum* and *Bellevalia flexuosa*, are exceptionally lifelike; only a few, such as those of *Ceterach officinarum* and *Oxalis cernua*, conspicuously fail to do justice to their subjects.

E. J. S.

Colours

And How we See Them. By Dr. H. Hartridge. Pp. xi+158+12 plates. (London: G. Bell and Sons, Ltd., 1949.) 15*s*. net.

THE six chapters of this book are mainly the content of the six Christmas lectures for children given by Prof. H. Hartridge at the Royal Institution in 1946. The treatment is therefore necessarily

popular and approximate, designed to keep within the comprehension of a juvenile audience. It cannot, therefore, be subject to the same criteria of criticism as a book professing to be an authoritative guide to serious students. Nevertheless, Prof. Hartridge has accomplished the task he set himself extremely well, and the lectures have been turned into a very readable account of an interesting and fascinating subject. Anyone desiring an introduction to the problems and phenomena of colour and colour-vision could not do better than read this book, which can scarcely fail to afford pleasure in the reading or to leave an abiding interest which will induce him to extend his study to the less elementary and more rigorous literature in which the subject abounds.

Although, as already indicated, the advanced worker on colour will not look here for guidance on theory, science teachers and lecturers will find the book a mine of useful information on effective and fascinating lecture demonstrations, especially demonstrations by projection. Many teachers, even in universities and technical colleges, fail lamentably in giving life and interest to the study of light by adequate demonstrations of an arresting character. Prof. Hartridge has included in the book descriptions of many of the excellent demonstrations which illustrated his lectures. These cover many branches of the subject, and most of them require only simple apparatus which should not be difficult to improvise, even from the resources of a school physics laboratory.

The book is well printed in easily legible type. The illustrations include portraits of Sir Isaac Newton (frontispiece) and Thomas Young. There are many line diagrams and twelve coloured plates. The diagrams, on the whole, are good, except in a few cases where simplification has been carried beyond tolerable limits. The colouring of the plates is rather crude; but this is not likely to mislead the reader. J. Guild

A Camera in Antarctica

By Alfred Saunders. Pp. 160 (72 plates). (London: Winchester Publications, Ltd., 1950.) 21*s*. net.

This book, a record of fifteen years of photographing in the Antarctic, is noteworthy for its really magnificent collection of illustrations. Whether he is showing his reader 'close-ups' of bird or animal, or of scenery, Mr. Alfred Saunders contrives to excel, not only as a photographer but also as an artist. The general standard is so high that it is not easy to single out illustrations, but there is on p. 70 a remarkable photograph of the wanderer albatross. This great sea-bird has a wing span of twelve feet, which, incredible as it may seem, is almost double the wing span of the male golden eagle. The eggs of the wanderer albatross, we are told, weigh 1 lb. and are good eating; only one egg is laid. The Antarctic summer is too short for the growth of the young albatross, which remains in the nest unfledged throughout the winter with its blizzards and severe frosts. It is supposed that during the winter the parent albatrosses do not visit their young, which subsist on their accumulated fat; but Mr. Saunders believes that they do occasionally return and feed the young.

There is a truly remarkable series of photographs of the various Antarctic penguins, and we are shown one of an Adelie penguin being pushed by its large chick during feeding operations to the very edge of a 600-ft. precipice. The author mentions that one day he saw two penguins which had evidently fallen over this cliff. They appeared almost lifeless, and, a few feet away, Skua gulls were waiting for them to die. Yet when he visited the place the following day he found the penguins had almost recovered, and were actually walking about. That a flightless bird should survive after a fall of 600 ft. is almost incredible, especially when the descent ended not on the water but on rocks. Seton Gordon

The Biochemistry of the Nucleic Acids

By Prof. J. N. Davidson. (Methuen's Monographs on Biochemical Subjects.) Pp. ix+164+4 plates. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1950.) 7*s*. 6*d*. net.

Prof. J. N. Davidson's little book, the first of a new series of 'Methuen Monographs', was published last autumn and has already proved its value to both research workers and students. It gives, in a short space, a very fair account of the chemistry and properties of the nucleic acids, leading to a fuller account of what is known of their function and metabolism. It is remarkable how much recent research he has managed to include in a small book. Although, as he points out in the preface, significant advances have been made since the book went to print and will no doubt continue, yet, broadly speaking, the emphasis is on recent work, and the serious student will find it an excellent introduction to the many researches which are going on.

It is a very remarkable fact that, although a close connexion with the processes of reproduction is suggested by the presence of nucleic acids in the chromosomes and in various particles which are known or suspected to be self-reproducing, and also by the close correlation between the onset of nucleic acid synthesis and the start of the mitotic cycle, no real clue has come to light as to their real function. Many workers have studied these compounds in the belief that they may perhaps discover in them the molecular nature of the gene, yet so far no one has been able to suggest a plausible method by which they could act in this way. All those biologists as well as chemists who want to know the real facts of the case could not do better than study this account.

The Complete Garden Handbook

By Maron J. Simon, John Elliott, Dickson W. Pierce and Beatrice P. Hendrix. Pp. xii+451+32 plates. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1950.) 37*s*. 6*d*. net.

The aim of the authors of this comprehensive volume is to give "information on every topic of interest to the gardener, including planning the garden, choosing flowering plants, shrubs and trees, and every step in practical gardening". It is designed for American readers and will no doubt be welcomed by them for its completeness and handy size. It is inevitable that many of the terms used sound strange to British ears, and it is to be hoped that the American habit of telescoping plant names wherever possible (for example, "Morningglory") will not spread across the Atlantic. The volume is lavishly illustrated in colour; but, it must be said, the standard of the plates, both in design and execution, is very low. It is difficult to imagine what value there could be in a picture, however good, of a single, unnamed, daffodil flower; but when this appears (Plate 11*B*) as an unrecognizable yellow 'star-fish' against a bright blue sky, the result is deplorable, and the majority of the plates are of much the same standard. J. S. L. Gilmour

HYPOTHESES RELATING TO THE BRAIN–MIND PROBLEM*

By Prof. J. C. ECCLES, F.R.S.
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FOR the purpose of this article the use of the term 'mind' will be restricted to 'conscious mind' in all its general operational field of perceiving, thinking, willing. As such, mind is a fact of experience, though for each of us only our own mind is an observable. It has been argued that the private and restricted nature of the observation eliminates mind from that class of observable phenomena which are publicly observable and hence by general agreement regarded as facts of experience. But all observation is, of course, just as private and restricted, the public character being given by symbolic communication between observers, in particular through the medium of language. The private observation of conscious mind in this manner achieves public status, and may therefore be ranked as a fact of experience. As such, observations relating to mind become a part of the raw material upon which scientific investigation may properly operate.

The Cartesian dualism of mind and matter necessarily involved the problem of how mind and brain could interact in perception and in willed acts. Most philosophers[1–3] now argue that the hopeless difficulties of this problem have rendered untenable both dualism and the interactionist view of brain–mind liaison. On the other hand, many men of science[4–6] find in dualism and interaction the most acceptable initial postulates in a scientific approach to the problem of mind and brain. In such an approach the question arises: What scientific hypotheses may be formulated that bear in any way on the hitherto refractory problem of brain–mind liaison? It should be noted that such hypotheses would represent an extension of natural science to a field of non-sensual concepts, and even to a field outside the matter–energy system of the natural world, as has been convincingly argued by Sherrington[5]. But also it should be noted that Adrian[6,7] has recently directed attention to the necessity for such an extension.

There are first various subsidiary hypotheses that have already been formulated, most notably by Sherrington[5] and Adrian[7] and which relate merely to the events in the brain when it is in liaison with mind.

(1) Mind liaison with brain occurs primarily in the cerebral cortex, though diencephalic centres may be also concerned, particularly as continued bombardment by impulses therefrom is necessary for sustaining activity in the cerebral cortex[8–10].

(2) Only when there is a high level of activity in the cortex (as revealed by the electroencephalogram) is liaison with mind possible. Unconsciousness supervenes instantly the activity is lowered (as, for example, in anoxia, anæsthesia, concussion, sleep[11–13]). Dreams are associated with bursts of electrical activity in the electroencephalogram[11].

(3) The uniqueness of each percept is attributable to a specific spatio-temporal pattern of neuronal activity in the cortex[6]. In general, any thought pattern in the mind has a counterpart in a specific spatio-temporal pattern of neuronal activity, which we may call the evocative neuronal pattern.

(4) Memory of all events is dependent on the development and persistence of increased excitatory efficacy across certain synaptic junctions. Lashley[14] has convincingly argued that "the activity of literally millions of neurons" is involved in the recall of any memory. There is a tendency for some particular spatio-temporal pattern of neuronal activity to be evoked by a particular predisposing or triggering neuronal activity and/or excitatory afferent input[6]. The remembered thought appears in the mind as the spatio-temporal pattern is being replayed in the cortex. This hypothesis has been recently supported by the finding that activation of monosynaptic paths in the spinal cord led to prolonged (measured in hours and possibly days) increase in the excitatory efficacy of synaptic knobs rendered specially sensitive by disuse[15]. It may therefore be postulated that the initial development of effectiveness in certain synaptic junctions is a sequel to the primal event that is remembered, and this effectiveness is sustained and even enhanced by each subsequent replaying in the brain (and remembering in the mind).

These four hypotheses relate to one and the other side of the apparently unbridgeable gulf between the matter–energy system of the brain and the 'non-sensual concept' of the mind which has remained unassimilable into the matter–energy system[5]. They describe the specific events in the brain which are linked with specific states in the mind, but say nothing concerning the 'how' of that linkage.

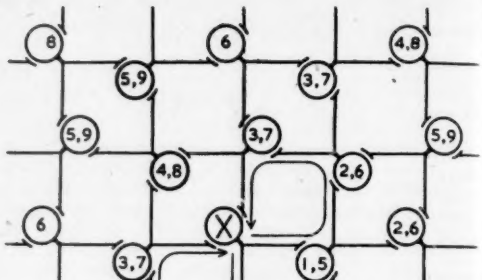
However, there is one partial approach to this key problem that hitherto has not been essayed. We can ask the question: How does it come about that liaison with mind occurs only in special states of the matter–energy system of the human* cerebral cortex? Is there any special property of this system that places it in a separate category from all the remainder of the matter–energy or natural world and even from its own matter–energy system when it is not in this special state of activity? It is here contended that such a special property in outstanding measure is exhibited by the cerebral cortex during consciousness, and the hypothesis is developed that the brain by this means enters into liaison with mind, having the property of a 'detector' that has a sensitivity of a different kind from that of any physical instrument. An introductory paragraph giving an outline of the essential structural and functional features of the neurones (nerve cells) of the cerebral cortex provides the necessary basis for an account of this special detector property, but for a full account various reviews may be consulted[8,16–21]. It is assumed that the functional properties of neurones in the cortex are similar to the motoneurones which have been extensively investigated in mammals. This assumption is justified by the essential similarity of structure and function that is revealed by investigations on cortical neurones[8–10,22,23].

* Substance of a lecture given to the Australasian Association of Psychology and Philosophy (Dunedin Branch) on April 12.

* In respect of the existence of rudimentary conscious minds of animals we must remain agnostic, for the essential information is necessarily derived by private observation and cannot be communicated to us by any animal, lacking as it does the means of adequate symbolic communication in language or otherwise.

The human cerebral cortex is essentially an extensive sheet of neurones about three millimetres thick, and with an average population of 40,000 neurones per sq. mm., there being in all about 10^{10} neurones[24]. Each neurone is *functionally* linked to many others by means of minute specialized areas of *contact* (synapses), there being formed in this way a complex functional network of neurones. Scattered over the surface of a neurone that forms a link in this network there are about a hundred synaptic contacts from other neurones, by any one of which it is a recipient of an excitatory influence when that neurone discharges an impulse thereto. When so activated adequately (a sufficient number of impinging impulses in a sufficiently short interval), the recipient neurone in turn generates an impulse which is discharged down its axon and thence exerts a brief excitatory action on the many other neurones (again perhaps about a hundred) by means of the synaptic knobs on its branching axon. After the generation of such an impulse a neurone passes through a depressed phase from which recovery gradually occurs in rather more than 0·1 sec.[21]. During this recovery phase it becomes progressively more susceptible to the excitatory effects of impinging impulses and again generates an impulse at the instant that the summed synaptic excitatory action reaches an intensity matching its excitability. If immediately preceding synaptic excitations have lifted a neurone to a sufficient degree of excitation, an impulse impinging at a synapse on its surface will initiate the discharge of an impulse after a delay of about 0·5 msec. However, if the excitation is at a lower level, then an impinging impulse causes merely a sudden raising of the excitation which, decaying with a half-time of two to three milliseconds, has virtually disappeared in 10 msec. The added complication produced by inhibitory synaptic action will be neglected for the present.

Lorente de Nó[16–18] has shown in diagrammatic form how the contacts obtaining between neurones in the cortex provide a system that could function as a complex net, the various neurones being at the nodes while the strands are woven from their numerous processes (dendrites and axons) that provide the multiple synaptic contacts. But before considering a net of such complexity, where each node is the convergent point of scores of paths and each in turn projects to scores of other nodes, it is useful to consider the properties of the simplest possible net of the type exhibited in the cerebral cortex (see accompanying illustration). Burns[19] has recently shown that the effects produced by electrical excitation of the cortex are explicable in terms of a similar type of net. Each neurone is assumed to have only two excitatory synaptic knobs on its surface and in turn to have an axon which has only two knobs on two other neurones. Further, it is assumed that the synaptic connexions so formed are of a pattern that allow the neurones to be schematically arranged in the rectangular net-like form of the illustration, where it will be noticed that there is virtually radial symmetry from any point, and the possibility of indefinite extension in every direction. If the allowance is three synapses per neurone, a similar construction with radial symmetry (based likewise on alternating direction of transmission, cf. successive rows of the illustration) would be possible in a three-dimensional network—and in general for n synapses per neurone in an n-dimensional network.



It will be seen that even the formalized and simplified neural network of the illustration potentially contains an enormous variety of neural circuits. For example, if neurone X discharges an impulse, the simplest circuits back to X are shown by the arrows, that is, there are two 4-neurone arcs, and next simplest are six 8-neurone arcs. In addition, it is potentially possible for a progressive invasion to spread over the net. The numerals on each neurone give the number of synapses traversed in leading to its first (and second) activation, there being with each a continued arithmetical progression of four due to the return circuits. In the operation of such a network it may be provisionally assumed that a single impulse impinging at a synapse on a neurone is adequate to generate the discharge of an impulse, and the probable value of 1·0 msec. may be assumed for synaptic delay plus conduction time to its own axonal terminals (the axonal length in the human cerebral cortex is very short for the majority of neurones[16–18]). Thus, there are chains with possible circuit times of 4 msec., 8 msec., 12 msec., etc., the so-called closed self-re-exciting chains[17]. Actually, such short circuits would be most improbable on account of the prolonged (at least 0·1 sec.) and deep (for 20 msec. or so) depression that a neurone suffers after discharge of an impulse.

During inattentive, but awake, states the predominating electroencephalogram rhythmic wave (the α-wave) at about ten a second indicates that the most probable circuit time of all those available approximates to 0·1 sec., that is, to the period needed for almost complete recovery of each neuronal element, and, allowing 1 msec. for each link, it would be expected that roughly there would be about a hundred neurones in one such circuit. But to conceive of such an isolated circuit is an abstraction, for, as here illustrated schematically, each link of any one circuit is held in common with a great variety of other circuits. At each neuronal node in the network impulses either may be ineffective excitors and hence be extinguished, or may fuse in their influence (synaptic summation), so generating a new impulse that in turn disperses to other nodes, there likewise to be extinguished or fused. During inattention much of this patterned activity appears

to be virtually random, adopting on the whole the dominant α-rhythm[4].

When the brain is active, for example, during perception, mathematical calculation or skilled action, this randomized activity with its approximate synchronization of large groups of neurones is broken up[4]. We may interpret this as due to the formation of specific spatio-temporal patterns of activity in the neural net. Sherrington[5] vividly and aptly pictures this net as an "enchanted loom where millions of flashing shuttles [the nerve impulses] weave a dissolving pattern, always a meaningful pattern, though never an abiding one; a shifting harmony of sub-patterns".

We have in imagination to develop the two-dimensional formalized net of the accompanying illustration to one of many dimensions, each node or neurone being at the confluence of many paths and itself projecting to many other nodes; and at each node the time of discharge is determined by the microscopic spatio-temporal pattern of the synaptic bombardments on its surface from millisecond to millisecond. The excitatory efficacy of the synaptic knobs of any one neurone will be related to its past usage. Hence, in response to certain spatio-temporal patterns of afferent input into the cortex, the developing cortical patterns will to some extent be determined by this developed structural specificity, as has already been discussed in relation to memory. That is, we are envisaging the pattern of activity in the cortex at any instant as being determined by two factors, the immediate (and very recent) input and the developed structural specificity (inherited and acquired). It is to be noted that unconsciousness is an invariable accompaniment of a net that, as shown by the electroencephalogram, is at rest or only active in low degree or active in a driven stereotyped way as in a convulsion of epilepsy or shock therapy that is, the net as such is not in liaison with mind. Adrian[6] even brings forward evidence that the part of the net giving the α-rhythm is not in liaison with mind. It is important, therefore, to fix attention on the special properties of the neural net during the specific patterned activity (as indicated by a rapid and irregular electroencephalogram) that occurs when there is liaison to mind.

Suppose some small 'influence' were exerted at a node that would make a neurone discharge an impulse at a level of synaptic excitation which would otherwise have been just ineffective, that is, in general to raise the probability of its discharge. Such a discharged impulse would in turn have an excitatory effect on all the other nodes on which it impinges, raising the probability of their discharge, and so on. If we assume, as above, that the spread from node to node occupies 1 msec., then even on the two-dimensional net of the illustration a spread to a large number of neurones is possible in, say, 20 msec., a time that is chosen because it is at the lower limit of duration of discrete mental events. It is to be remembered that the neurones of the network are at a high level of excitation, as there is initially a large amount of circulating activity (impulses) in the network. Potentially the number of neurones that could be involved would be given by the formula: $2m^2 - 2m + 2$, where m is the number of nodes traversed, that is, twenty in the 20 msec., so the potential number of neurones is 762. With a multi-dimensional network the number of neurones, N, is given, when m is large relative to n, by the general formula, $N \sim \frac{2^n}{n!}\ m^n$, which for $m = 20$ (that is, 20 msec.) and for $n = 4$ (that is, each neurone the receiver and giver of four effective synaptic contacts) gives a total of the order 10^5 neurones involved in 20 msec., and for $n = 5$ the total is of the order 8×10^5. These calculations are intended merely to give some indication of the large number of cortical neurones that could be affected by a discharge originating in any one. When a high level of activity prevails in the cerebral cortex, it may be conservatively estimated that, out of the hundred or more synaptic contacts made by any one neurone, at least four or five are effective in evoking the discharge of neurones next in series. The remainder would be ineffective because the respective neurones would not be poised at this critical level of excitability. So long as the assumed number of effective connexions for each neurone is kept at such values, it is probable that the conventions of the network structure give an approximate method of allowing for all the mass of feed-back connexions that occur in the closed chain linkages of the cerebral cortex[16,17]. Since the cortex is approximately 3 mm. thick and the mean density of neurones 40,000 per sq. mm. of surface[24], the spread to some hundreds of thousands of neurones can be treated as spreading indefinitely in all directions without restriction by the sheet like structure of the cortex.

An alternative method of calculation may be based on the experimentally observed rate at which a wave of excitation spreads radially through the cortical network from an artificially stimulated focus[9,10,23]. The all-or-nothing character of the spread indicates that during the invasion almost all the neurones are being excited to discharge impulses. Basing the calculation on the value of 50,000 neurones per sq. mm. (the average for gyri[24]), an initially excited focus of 1 mm. radius would include about 150,000 neurones, and at the observed radial rate of spread of 20 cm. per sec. there would be a total invasion of about 4×10^6 neurones in 20 msec. The invasion of each neurone is attributable to the converging excitatory impulses that impinge on it and cause it to discharge. By means of the many synaptic terminals of its axon each of the initially excited neurones thus contributes to the invasion of many neurones and each of these in turn to many more, and so on for the twenty or so successive neurone discharges that occur along an outward spreading chain in 20 msec. Again we have the indication that an impulse discharged by any one neurone has in 20 msec. contributed directly and indirectly to the excitation of hundreds of thousands of neurones.

Thus, within 20 msec. the pattern of discharge of even hundreds of thousands of neurones would be modified as a result of an 'influence' that initially caused the discharge of merely one neurone. But further, if we assume that this 'influence' is exerted not only at one node of the active network, but also over the whole field of nodes in some sort of spatio-temporal patterning, then it will be evident that potentially the network is capable of integrating the whole aggregate of 'influences' to cause modification of its patterned activity that otherwise would be determined by the pattern of afferent input and its own inherent structural and functional properties. Such integration would occur over hundreds of thousands of nodes in a few milliseconds, the effects exerted on any and every node being correlated in the resultant patterned activity of the surrounding

hundreds of thousands of neurones. Thus, in general the spatio-temporal pattern of activity would be determined by three factors: (1) the micro-structure of the neural net and its functional properties; (2) the afferent input; (3) the postulated 'field of extraneous influence'. It can be claimed that no physical instrument would bear comparison with the postulated performance of the active cerebral cortex as a detector of minute 'fields of influence' spread over a microscopic pattern and with temporal sequences of milliseconds. The integration, within a few milliseconds, of 'influences' picked up at hundreds of thousands of nodes would be unique, partieularly when it is remembered that the integration is no mere addition, but is exerted to modify in some specific way "a shifting harmony of sub-patterns" of neuronal activity, achieving expression through the modifications so produced.

Thus, the hypothesis is that mind achieves liaison with the brain by exerting spatio-temporal 'fields of influence' that become effective through this unique detector function of the active cerebral cortex.

When the cortex is at a low level of activity, it would function inefficiently as a detector on account of the small proportion of neurones poised at the critical level of excitation and the consequent improbability of an effectively spreading influence; hence an explanation is provided for the invariably observed failure of mind–brain liaison when the electroencephalogram reveals depressed cortical activity. An explanation is also provided for the loss of consciousness in the stereotyped and driven cortical rhythms that occur in convulsions, for the nodes of the cortical network would also then lack the critical poise as well as the specific patterning. It is further to be noted that according to the hypothesis only a part of the cortex is needed for liaison with mind. It may be that any area that is in the critically excited state will do. This corresponds to the clinical evidence that mind–brain liaison is not interrupted by excision of a large part of the cerebral cortex, or when a large part is occupied by activity that excludes liaison, for example, by a convulsion or even by alpha wave activity[6]. Maybe less than a tenth of the neurones in the right state of activity is enough to give an effective mind–brain liaison.

When considering the manner in which mind could operate on matter, Eddington[4] discussed two hypotheses. In the first, it was postulated that mind could control the behaviour of matter within the limits imposed by Heisenberg's Principle of Uncertainty. Eddington rejected this partly because the permitted range would be exceedingly small. Presumably he was thinking of an object as large as a neurone. However, a neurophysiologist would consider the much smaller synaptic knob as the key structure on which a 'mind influence' might work. The synaptic knob is approximately a sphere $1{\cdot}3\ \mu$ in diameter[25] and so would have a mass of 10^{-12} gm. If, as Eddington implies, the uncertainty principle is applicable to an object of this size, then it may be calculated that there is an uncertainty in the position of such an object of about $1{\cdot}5\ m\mu$ in 1 sec. and $0{\cdot}2\ m\mu$ in 20 msec. Such distances are very small; but it is conceivable that the excitatory efficacy of a synaptic knob would be appreciably affected by an uncertainty of this order, for the distance between the knob and the subjacent membrane is probably less than 100 mμ, and the excitatory efficacy would be expected to be very sensitive to changes in this value, at any rate on the electrical hypothesis of synaptic transmission[20]. Furthermore, as shown above, minute 'influences' thus exerted on a large population of neurones would be rapidly integrated in the form of a changed spatio-temporal pattern of activity in the neural net. There is thus in the active cortex a mechanism that could effectively amplify by thousands of times minute effects exerted on the individual synaptic knobs. It is therefore possible that the permitted range of behaviour of a synaptic knob may be adequate to allow for the effective operation of the postulated 'mind influences' on the active cerebral cortex. However, Eddington rejected this hypothesis for the further reason that it involved a fundamental inconsistency. First, behaviour according to chance was postulated in making a calculation of the permitted limits according to the uncertainty principle, then it was restricted by a non-chance or volitional action (the mind influence), which necessarily must be introduced if mind is to be able to take advantage of the latitude allowed by the uncertainty. Hence, Eddington was led to an alternative hypothesis of a correlated behaviour of the individual particles of matter, which he assumed to occur for matter in liaison with mind. The behaviour of such matter would stand in sharp contrast to the uncorrelated or random behaviour of particles that is postulated in physics, and may be "regarded by us as something 'outside physics'"[4]. Either of Eddington's hypotheses could form the physical basis of the neurophysiological hypothesis that has here been developed for mind–brain liaison. This latter hypothesis has the merits of relating the occasions when the mind can operate on the brain to the observed cortical events during consciousness, and of showing how an effective action could be secured by a spatio-temporal pattern of minute 'influences'.

In brain–mind liaison the traffic is both ways, from brain to mind no less than from mind to brain. Existing knowledge of the brain provided the basis for the above hypothesis relating to the operation of the mind on the brain. The reverse traffic—brain action to mind—is still more perplexing; but, presumably, if the mind can operate on dynamic spatio-temporal patterns of activity in the cortex, it would be expected to be susceptible to operation in the reverse sense. That would be the operational path in all perception and in the memory of events.

It will be sufficiently evident that the hypothesis here developed is of a fragmentary and tentative character, but it is hoped that it may be of value in further theoretical developments on mind–brain liaison. An outstanding problem for consideration would concern the postulated action of the mind in a spatio-temporal pattern, for presumably it must so act if it is to cause significant modification in patterned activity of the cortex. However, that problem would appear less formidable if there were a sufficiently rapid and detailed feed-back from brain action to mind, which in any case must be assumed for perception.

It will be objected that the essence of the hypothesis is that mind produces changes in the matter–energy system of the brain and hence must be itself in that system. But such a deduction is merely based on the present hypotheses of physics. If these 'mind influences' were of a nature that precluded their detection by any existing physical instrument, then physicists would be ignorant of them, and the hypotheses of physics would necessarily neglect them. It is at least claimed that the active cerebral cortex

could be a detector of such 'influences' if they existed. But there are also now extensive reports of well-controlled experiments that give evidence of a quite different kind that there is a two-way traffic between mind and the matter–energy system. Of particular significance for the above hypothesis of mind influence on brain are the psycho-kinetic experiments[26]. These experiments as described leave little room for doubt that very slight changes can be produced by some minds on moving physical objects such as dice, effects which are revealed only when statistical analysis is applied to relatively long series of trials. In particular, the striking decline in effectiveness with time would seem to exclude all physical factors. There are, too, the even better authenticated experiments of the complementary process called extra-sensory perception[26,27]. If these experiments are revealing facts, there is an interaction of physical events with mind, as indeed is also indicated above by Eddington's second hypothesis. If as men of science we reject these experiments, it should be done on the basis of established errors in their execution or interpretation. Such errors have evaded years of careful scrutiny by unsympathetic critics. It will be agreed with Rhine[26] that, if the so-called psi-capacities (psycho-kinesis and extra-sensory perception) exist, they provide evidence of slight and irregular effects which are precisely of the nature that must be postulated for brain–mind liaison, but which occur there in highly developed form. The present hypothesis would offer an explanation for this high development of matter–mind traffic in the active human cerebral cortex, the development including not only continuous operation but also exquisite subtlety in transmission. Both these features would receive explanation on the basis of the interlocking, integrating and ever-changing pattern of activity formed by the multiple (ten thousand million-fold) detectors that exist in the cortex during consciousness.

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THE WEST AUSTRALIAN FLORA*

By Sir EDWARD SALISBURY, C.B.E., F.R.S.

IN order to appreciate the character of the Australian flora it is necessary to realize first of all the influence of the extent of this vast continent isolated by large stretches of ocean from the nearest land mass. The localized distribution in Australia of large centres of population is a sufficient indication of the markedly peripheral distribution of situations favourable to human activity. Indeed, it is true that only about 15 per cent of the total of nearly three million square miles, which is approximately the area of Australia, has a rainfall of more than thirty inches, and this has to be considered in relation to the high and sometimes very excessive summer temperature. Furthermore, the average rainfall data in Australia are perhaps even more misleading than most averages, for nearly half Australia has a rainfall variability of 40–50 per cent, and even in the more habitable parts a variability of 20 per cent is by no means infrequent. In other words, the greater part of Australia is arid for a shorter or lengthier period, and the more arid region, abutting as it does upon the north of the Great Bight which reaches to the Nullabor Plain, means that Western Australia is isolated on the east by thousands of miles of desert as effectively as it is on the west by thousands of miles of ocean. Thus Western Australia is only capable of supporting in its central region specialized vegetation of an extreme xerophyllous type. Western Australia is, in fact, almost isolated from all the most favourable areas for vegetable growth except for its own south-west corner, where temperate rain-forest occurs.

A further point of some importance is that many of the soils in the southern and central parts are comparatively recent. In common with the most favourable areas for vegetation, the geologically ancient areas are likewise marginal. It is therefore scarcely surprising, when we consider all these facts together, that we find the flora of Western Australia is as a whole, like other isolated areas of far smaller extent, characterized by the high proportion of endemics which it comprises, amounting to about 85 per cent of the total.

Nevertheless, despite the isolation of Australia as a whole and of Western Australia in particular, the flora shows affinities with those of South America and South Africa. The facile explanation that some authorities have favoured that the former Antarctic Continent provided land connexions for the migration of a common flora between Australia, South America and South Africa would appear to be an anachronism of wishful thinking, since there is no evidence that the flowering plants, as we understand that group to-day, were differentiated until long after such land connexions had ceased to exist, and indeed the extensive Cretaceous transgression of the ocean that rendered the separation of these areas probably much greater than to-day occurred about the time that the Angiosperms perhaps evolved.

One family, rich in endemics, that is especially a feature of Western Australia, is the Myrtaceæ. Members of this family have a wide distribution in warm regions, but the genus *Eucalyptus* with some three hundred species is almost confined to Australia with many species only found in the west, and one of the most beautiful of these endemics is *Eucalyptus macrocarpa*,

* Substance of a Friday evening discourse delivered at the Royal Institution on May 18.

with large red flowers. Other striking members endemic to Western Australia are the Geraldtown wax flower (*Chamælaucium*), and above all the beautiful fringe flowers (*Verticordia*) which adorn with their dainty blossoms the arid sandy heaths of the West where more than three-quarters of the forty known species are alone to be found. They owe their name to the fringe-like sepals, and in some species the petals are dissected also. The genus *Calothamnus* comprising twenty-five species is entirely Western Australian, and all these exhibit leaves highly resistant to desiccation.

The Proteaceæ is one of the most characteristic families of the Australian flora, and this group would appear to have had a wide distribution in Tertiary times. Although many of the so-called proteaceous fossil leaves are of dubious attribution, there seems little doubt that the family was formerly represented in the northern hemisphere, as the late Sir Albert Seward, after a critical assessment of the evidence, concluded. Moreover, recent studies in Australia have shown that the family even there had a more extensive distribution than to-day. The present geographical range is wide over the southern hemisphere but discontinuous, with concentrations in South Africa and Australia; but by far the largest number of endemic species are located in Western Australia. It is therefore difficult to escape the conclusion that this is an ancient family that has experienced a diminishing range and increasing differentiation through the past thirty million years of its history. It is a specialist family peculiarly fitted for growth in conditions of great seasonal aridity and correspondingly unfitted for competition with the more vigorous and faster growing types in conditions more favourable to plant growth. Thus the increasing restriction of this family is probably to be attributed to ecological causes: the climatic differentiation of recent epochs which, combined with soil development, have produced localized areas that constitute the sanctuaries for its survival.

Of the total of fifty genera in this family it is true that only five are confined to Western Australia, the most important being the genus *Dryandra*, with some fifty members, but altogether more than 370 species of Proteaceæ, or almost two-fifths of the entire family, are restricted to this area.

The foliage of the Western Australian proteaceous trees and shrubs is uniformly leathery in texture, but may be needle-like and unbranched as in some species of *Hakea*, or broad and flat as the leaves of *Banksia menziesii*; but, in all, the foliage shows but little change when dried. This is due to the rigid interior skeleton and robust epidermis, which offer a great mechanical resistance to desiccation. The surface is covered with a thick cuticle almost impervious to water vapour, and the stomata are usually sunk in pits and often protected by perforated domes of cuticle which diminish the effect of hot, dry winds. It is noteworthy that a branch of *Dryandra* that has been detached from the plant for more than a year retains the form of its leaves almost unaltered, thus bearing witness to the mechanical resistance to shrinkage and so to loss of water vapour.

It is this same adaptation to drought conditions that is doubtless responsible for the striking similarity of growth habit which is often exhibited by species of different genera and families. I was much impressed by this feature in a heath-like area of scrub towards the edge of the Nullabor Plain, where the average rainfall was between 10 and 15 in. per annum. Here members of a number of families showed a marked similarity of vegetative structure sometimes so close as to render them almost indistinguishable, except by the expert, when not in flower. Such epharmony is particularly well exemplified by the ericoid habit, not only shown as we should expect by the Epacridaceæ but also by *Hibbertia hypericoides* (Dilleniaceæ), *Leschenaultia formosa* (Goodeniaceæ), *Boronia megastigma* and *Thryptomera* sp. (Myrtaceæ), *Acacia rossii* (Leguminosæ), *Eremophila* (Myopocaceæ), *Petrophila ericifolia* (Proteaceæ), and even by the Liliaceæ in that remarkable shrub *Calectaria cyanea*, to mention but one representative from seven different families; but this list could be extended almost *ad nauseam*.

Again, the switch-like habit in which the leaves have undergone extreme reduction is paralleled in a number of quite unrelated species. Examples are furnished by the phyllodic species of *Acacia*, where the function of the leaves is assumed by green modified leaf stalks or flattened stems; and by the she oaks (*Casuarina*), looking like woody horsetails with minute leaves on green longitudinally grooved stems, these grooves providing shelter for the stomata, which are further protected by the presence of hairs. The Restionaceæ is a particularly characteristic Australian family, where the stems also perform the function of leaves.

Alike in these plants the assumption of the leaf function by stem or leaf-stalk has resulted in an increase of mechanical resistance to water-loss and thus in a prolongation of photosynthetic activity.

The shelter afforded by a felt-like covering of woolly hairs which protects the surface of the plant from direct wind action is well exemplified in the Verbenaceous genus *Lachnostachys*, aptly known by the popular name of lamb's tails. Here the white appearance, which the air-filled hairs confer, bears witness to the large amount of the incident light which is reflected and thus enhances the protection that the hairs afford. As a second example mention may be made of the flannel flowers (*Actinotis* sp.), which belong to the Umbelliferæ and recall the edelweiss of the European flora.

The succulent habit is not commonly represented except in the saline areas, where perennial members of the Chenopodiaceæ such as *Salicornia australis* are frequent and exhibit this feature, as also annual species of *Zygophyllum*.

The extreme habitat conditions call forth a similar adaptation for resistance to water loss in such an unlikely group as the Liliaceæ. The Western Australian representatives of this family includes two arboreal genera, namely, the blackboys, *Xanthorrhœa*, and the grass tree, *Kingia australis*. These both have long grass-like leaves internally supported by sclerotic tissue. In the triangular or quadrangular leaves of the blackboys there is a thick investment of woody tissue just beneath the surface that resists shrinkage. In *Kingia* there are in addition internal woody bands that augment the resistance to shrinkage and thus to the escape of water vapour. It should perhaps be emphasized, what is too often overlooked, that the so-called transpiration checks are mainly of importance as prolonging the period of photosynthetic activity and thus fulfil their purpose, even if the leaf eventually wilts or even dies. In order to emphasize that death may not result from extreme desiccation my own experience with *Kochia tomentosa*, one of the Western Australian salt-bushes, is worth recording. I gathered a piece of this plant and, being uncertain of its identity, retained a small sprig and placed this

in my pocket-book, where it remained in a very dry and brittle condition for three weeks while I was travelling by a roundabout route to Adelaide via Melbourne and the Murray Valley. It was then packed up with some papers and dispatched to England, where it remained in a centrally heated room for some months. Then taken out, it was inadvertently placed on the top of a cupboard in an unheated room during a spell of foggy weather. When found a week later it had put out some small shoots of diminutive new leaves. What osmotic suction it had attained I hesitate to guess.

The so called protocorm of that unique Australian lycopod, *Phylloglossum drummondii*, to which such importance was attached during the phylogeny hunting of the early years of this century is probably only biologically significant as presenting another adaptation to an intermittently arid environment that we see so strikingly developed in the tuberous sundews. British sundews, which grow in permanently damp places, have a meagre root system, but these Australian sundews, which grow in areas that are under water in winter but become dry and arid sandy wastes in summer, seem invariably to possess an underground tuber two to six inches beneath the surface according to the species. From such a hard round tuber arise the long stems of the climbing species that deck the branches with their glistening leaves and bear at the summit large white, pink or even yellow flowers. The sundews are particularly well represented and very diverse in character. *Drosera macrophylla* has a rosette of large leaves which together with the white flowers arise from a black tuber about half an inch in diameter and four or five inches deep. Some are like our own species, while *Drosera gigantea* suggests a sea lavender with numerous small white flowers on a richly branched inflorescence that arises from a deeply seated black tuber of elongated form. This tuberous habit can be regarded as a means of evasion of the climatic extremes, and can hence be compared with the annual habit so well exemplified by the ephemeral Compositæ of the desert areas that compass their whole life-history in a few weeks after the infrequent rains. These composites paint the desert like a Joseph's coat of many colours, and not the least interesting feature is the marked dominance of one species over a considerable area, so that you may get square miles looking white with the presence of *Helipterum niveum*, while farther on are acres which are yellow or red through the dominance of other species. What the factors are which determine this dominance is uncertain. Very often there is no obvious soil difference to account for this. Like most desert annuals, the Australian species are short-lived plants which germinate during appreciable rain and pass their whole life-history within a few weeks. If, as may well happen, no appreciable rain falls, the seeds remain dormant until conditions become more suitable; but the abundance of these annuals bears witness to the relative fertility of the soil and to the limiting conditions upon vegetation which are imposed by the vagaries of the climate.

The sandy coastal plains are chiefly characterized by their poor soils, consisting of alluvial deposits so notoriously deficient in nutrient salts as to produce herbage inadequate for the support of healthy sheep and stock and responsible for the coastal diseases. We now know that these are the outcome of deficiencies, especially in the trace elements copper, zinc and cobalt. The last, though only requisite in amounts measured in parts per ten million of the food eaten, is now known to be essential to the well-being of ruminants, while zinc and copper are, in amounts of similar diminitude, essential alike to plant growth and animal welfare. The spraying of spruce trees with very dilute solutions of zinc sulphate has a most spectacular effect on the rate of growth of this tree on these soils. This response is indicative of the influence that such deficiencies may exert on competition on one hand between species that are tolerant of meagre rations of these trace elements or particularly efficient in their appropriation from inadequate supplies, and, on the other, those species that make greater demands for such upon the soil or are perhaps less efficient in their exploitation.

Not the least interesting feature of the Australian flora is the way in which species after species introduced from the Mediterranean or South Africa has 'run amok' in those areas where man has disturbed the natural vegetation.

It is possibly true in Australia, as the late Dr. Cockayne said of New Zealand, that the native species are quite capable of holding their own against introductions except where man disturbs the natural conditions. The native species are, in fact, specialists, peculiarly fitted to the natural environment. But certain it is that in the areas occupied by man or materially disturbed by him the introductions have established themselves in Australia in a most spectacular way. Near Humbug Scrub, not far from Adelaide, one can see many acres of pasture almost completely occupied by the globe artichoke, which, beautiful though they are in flower, are apparently of little value. Again, the Mediterranean bugle, *Echium plantagineum*, has been encouraged in some of the arid areas as providing fodder during the dry season, and here it rejoices in the name of "Salvation Jane"; but one sees potentially good pastures ruined by its superabundance in the region of Port Augustus, and here it is called "Patterson's Curse"! The many acres which it there covers with its blue flowers are to the mere visitor a charming sight. Again, the South African *Oxalis cernua* was introduced into Australia as a garden plant and was at one time sold at 4*s*. 6*d*. a root. To-day one can see citrus orchards in which the whole of the ground among the citrus trees is one continual sheet of yellow with its brilliant flowers, and soursop, as it is called, has likewise become a pest in many parts. To-day, too, one can see in southern Western Australia the arum lily (*Richardia*) occupying the ditches, and tall species of *Watsonia*, constituting what might almost be described as thickets, and species of *Homeria* rendering poisonous the pastures they infest. It is no wonder that Australians to-day hesitate to grow even the most beautiful of the South African plants for fear they should get out of hand and become one more pest added to the unwelcome invaders. One has only to see the swamps in Western Australia invaded by arum lilies or the exuberant species of *Watsonia* to realize how easily erstwhile garden plants can become a curse.

If we consider the flora of West Australia in its wider aspects we cannot but be struck by the fact that it is at once highly specialized, but small and restricted in character in relation to the area involved. Despite its million square miles the total vascular flora numbers only about 5,800 species. It is true that much of Western Australia is desert; but a large part of this carries its own specialized flora. To apprehend the relative paucity it is sufficient to state that the whole of France with scarcely one-fifth

of the area of Western Australia has a flora containing nearly five thousand species or roughly five-sixths, and comprising a far greater diversity of genera. The flora of France comprises more than 884 genera compared with only about 560 genera in the flora of Western Australia. Still more significant is that South Africa, with a similar area to Western Australia, has more than twice the number of genera. Isolation has thus on one hand permitted a high degree of specialization; but this has progressed in a much less varied biological community than would obtain in an area that had not been isolated and may well account in large measure for the vulnerability of the Western Australian flora to competition from immigrants when conditions of their environment are changed.

NEWS and VIEWS

Physics at Queen's University, Kingston, Ontario: Prof. J. K. Robertson

After forty years of faithful and constructive service, Prof. John Kellock Robertson, head of the Department of Physics at Queen's University, Kingston, Ontario, has resigned. Prof. Robertson was born in Perth, Ontario, in 1885. He attended the local schools and entered the University of Toronto, where he graduated in 1907, and later served as demonstrator in the Department of Physics. He was appointed lecturer in physics at Queen's University in 1909, and except for two years when he was absent at Cambridge during 1912–13 and at the Imperial College of Science and Technology, London, as visiting professor during 1933–34, he has worked there ever since, becoming head of the Department in 1943. He received the degree of doctor of laws at the spring convocation this year at Queen's. For many years he was a member of the Faculties of Arts, Engineering and Medicine—something almost unique in Queen's administration. His lectures on optics were well known, but he achieved the greatest distinction in his courses for medical students. He was elected a Fellow of the Royal Society of Canada in 1926, served as secretary of Section III for several years and was elected president of that Section in 1942–43; finally, in 1944, he was elected president of the Society.

During his long career, Prof. Robertson has found time to write many papers and books. Among the books should be mentioned a volume on physical optics which appeared in 1929 and has gone through three editions. This is an exceptionally readable and comprehensive text and is a very useful introduction to the subject. His book on X-rays and X-ray equipment is designed primarily for medical students and practitioners. Of a less formal character is a charming little book entitled "Atomic Artillery", the title of which tells its scope. His research interest, as shown by numerous papers, has been in the field of discharges in gases and vapours excited by high-frequency and micro-waves. For many years he served on the editorial board of *Queen's Quarterly* and has contributed articles to this and other journals. Prof. Robertson will be remembered by many graduates as an enthusiastic and inspiring teacher. Those who were fortunate enough to work with him in his own laboratory have been profoundly impressed and form a group of progressive and resourceful young physicists. In his retirement he has left Canada to live with his daughter, who has resided in London for a number of years.

Prof. B. W. Sargent, M.B.E.

Dr. B. W. Sargent, who is succeeding Prof. J. K. Robertson, leaves the post of assistant director of the Physics Subdivision, Atomic Energy Project, Chalk River, Ontario. Born at Williamsburg, Ontario, in 1906, Dr. Sargent received his early education in local schools and at Queen's University, where he obtained his B.A. in 1926 and M.A. in 1927. Following graduation, he spent two years at Queen's doing research in radioactivity under the direction of Prof. J. A. Gray, Chown research professor. The award of an 1851 Exhibition Scholarship in 1928 enabled him to spend the next two years at Cambridge, where he continued research in radioactivity at the Cavendish Laboratory under Lord Rutherford. His work there on beta-ray spectra and related problems led to an important relation known as Sargent's Law. In 1930 he returned to Canada as a lecturer in physics at his *alma mater*. For the next thirteen years he combined teaching duties with research so successfully that in 1941 he was elected a Fellow of the Royal Society of Canada. In 1943 he was granted leave of absence to join the Atomic Energy Project, Montreal Laboratory, under the National Research Council of Canada. Resigning from the staff of Queen's University in 1946, he has remained with this group until the present time; during 1945–50 he was head of the Nuclear Physics Branch, first at Montreal, then at Chalk River, and since January 1, 1951, he has been assistant director of the Physics Subdivision there. Dr. Sargent is an authority on problems relating to neutrons and to heavy-water piles, and has published papers on these and other subjects.

U.S. Navy Aviation Medical Acceleration Laboratory: Prof. Robert F. Rushmer

The University of Pennsylvania and the U.S. Naval Air Development Center at Johnsville, Bucks County, Pa., have announced the appointment of Dr. Robert F. Rushmer, of the University of Washington, Seattle, Washington, to be superintendent of the Scientific Department at the new Aviation Medical Acceleration Laboratory of the U.S. Navy. This Laboratory is one of the five laboratories of the Naval Air Development Center, which has made an agreement with the University of Pennsylvania whereby there is to be mutual exchange of personnel and facilities between the two institutions. Dr. Rushmer has also been appointed professor of applied physiology in the Faculty of Medicine, University of Pennsylvania; others appointed to the Aviation Medical Acceleration Laboratory will also receive appropriate faculty appointments in the University. The new Laboratory is at Johnsville, approximately eighteen miles north-east of Philadelphia, and its main functions will be the study by naval and civilian medical authorities of man's reactions to acceleration under conditions closely resembling the stress patterns encountered in actual air combat. The Laboratory has been designed as a complete aero-medical laboratory, well equipped for work in physiology, animal surgery, radioactivity, biophysics, biochem-

istry, gas analysis, pathology and electronics, a medical library, conference rooms, service and fabrication shops.

Dr. Rushmer is a native of Ogden, Utah, where he was born in 1914. He graduated from the University of Chicago in 1935 with a science degree and from Rush Medical College in 1939 with a medical degree. During 1940–42 he studied at the Mayo Clinic, Rochester, Minnesota, with a fellowship in pædiatrics. In 1941 Dr. Rushmer was appointed an assistant in aviation medicine at the Mayo Foundation, and he served as a research projects officer in the Department of Clinical Investigation, AAF School of Aviation at Randolph Field, Texas, during 1942–46 inclusive. After the War, Dr. Rushmer joined the medical faculty of the University of Southern California as an associate professor of aviation medicine, and in 1947 he took up a similar appointment in the University of Washington.

Royal Society of Edinburgh: Honorary Fellows

At a meeting of the Royal Society of Edinburgh held on July 2, the following were elected Honorary Fellows of the Society.

British: Sir Charles Harington, director of the National Institute for Medical Research; Sir Harold Spencer Jones, Astronomer Royal.

Foreign: Prof. George W. Corner, director of the Department of Embryology, Carnegie Embryological Laboratory, Baltimore; Prof. H. A. Kramers, director, Institute of Theoretical Physics, Leyden; Prof. Vincent du Vigneaud, professor of biochemistry, Cornell University Medical School, New York; Prof. Sewall Wright, professor of zoology, University of Chicago.

Prof. E. L. Hirst delivered the Bruce–Preller Lecture, his subject being "The Synthesis and Functions of Sugars in Plant Life". The Makdougall–Brisbane Prize (1948–50) was presented by the president to Prof. James Small, Queen's University, Belfast, for his papers dealing with quantitative evolution, two of which have been published in the *Proceedings* of the Society during the period of the award.

Development of Atomic Energy in Great Britain

In the House of Lords on July 5, Lord Cherwell put forward a motion regretting "the slow progress made in this country in developing atomic energy for peaceful and for war-like purposes", and asking for the transfer of the work from the Ministry of Supply to a special organization "under the direct control of the head of the Government". He remarked that the matter had become more urgent in view of the impending retirement of Lord Portal, director of atomic energy, whose chief scientific adviser had already left the service. The Civil Service, he said, is unfitted for dealing with this kind of undertaking; and a more flexible organization is required. Many good engineers and scientific men are reluctant to join the Civil Service because their work would be regulated by the administrative side, which knows little about the subject. Lord Cherwell also referred to security measures, which he believes are inadequate as applied in this field. No other country, he said, has attempted to carry on research and development in atomic energy through a government department, and he asked for a change of organization as a matter of urgency.

The Government reply was by Viscount Alexander, chancellor of the Duchy of Lancaster. He remarked that the Government is quite prepared to change its views on this important matter if it is convinced that progress is being held up in any way. In point of fact, however, the Sellafield development, he said, has been completed well within the time schedule. Any new organization would be faced with the same shortages and frustrations due to post-war difficulties which have hampered not only the Civil Service but also every part of industry in Great Britain. Further, he believed that a change of organization at the present time would cause considerable disturbance and set back the atomic energy project by months. He claimed that under the Ministry of Supply there has been no delay in decisions on policy, no lack of money and, until recently, no difficulty in recruiting a proper share of the country's scientific men. The Prime Minister had given instructions that the project was to have the highest priority, and it has been conducted on the largest scale possible in view of the country's resources. The present arrangements, Lord Alexander said, do not preclude a close degree of personal attention by the Prime Minister. Lord Cherwell's motion was carried by 52 votes to 31.

British Coal Utilization Research Association: Annual General Meeting

The successful fusion in Great Britain of the research interests of the nationalized coal and electricity industries with those of the independent appliance manufacturers and coal consumers in an autonomous co-operative research association was referred to by Sir Charles Ellis during the course of his presidential address at the annual general meeting of the British Coal Utilization Research Association held on June 13 at Leatherhead. Introducing the annual report of the Association for 1950, Sir Charles, after commenting upon the success of the system of committees by which the affairs of the Association are conducted, and upon the satisfactory financial position, reviewed briefly a few of the more outstanding activities and achievements of the Association during the year. The investigation into the effect of coal characteristics upon the performance of shell boilers, for example, had provided quantitative data on the beneficial effect of using coal of the correct moisture content; studies of the performance of gas producers had revealed a promising new method of automatic control based on an instrumental link between coal feed and off-take gas temperature; a new study of the gasification of slurries had been commenced; work was progressing on the design of a cyclone furnace which should provide not only a power source for a gas turbine, but also a method for the economical combustion of coal intermediate in size between normal boiler fuel and pulverized fuel; and the work on domestic heating was being directed towards the achievement of smokeless combustion in open fires. Finally, Sir Charles Ellis announced the establishment of an annual Coal Science Lecture, believed to be the first ever inaugurated by a research association, and announced that Sir Alfred Egerton had been invited to be the first lecturer.

Regulations concerning Full-time Work in the Colonial Service

One of the constituent institutes of the Joint Council of Professional Scientists recently directed the Council's attention to the varying interpretations, in respect of men of science in the service of Colonial Governments, which are placed on paragraph 52 of Colonial Regulations (Colonial No. 88–1 of 1945),

namely: "An officer whose remuneration is fixed on the assumption that his whole time is at the disposal of the Government is prohibited from engaging in trade, or employing himself in any commercial or agricultural undertaking". While agreeing that it is undesirable for servants of Colonial Governments to act as consultants to industrial firms, the Joint Council expressed the view to the Colonial Office that it was not in the best interests of the Service for this rule to be interpreted in such a way that it would prevent a scientific worker acting, for example, as a university examiner or undertaking other academic work or contributing to scientific literature in the ordinary way. The Council's view was that much would be gained if scientific members of the staff of an establishment were free to undertake such extra-mural work as the director of research, or other responsible officer, expressly approved, and if these directors and officers had wide discretion in authorizing such work and in deciding what extra-mural activities they themselves should undertake. These views were submitted to the Colonial Office in a document signed by its chairman and the presidents of its four constituent bodies: the Institute of Biology, the Royal Institute of Chemistry, the Institution of Metallurgists and the Institute of Physics.

The Assistant Under-Secretary of State for the Colonies in charge of research, both in interview and in correspondence, pointed out that it is a matter of common practice for scientific officers in the service of Colonial Governments to contribute to scientific literature, and in the same way other officers frequently publish matters not excluded by the terms of the Colonial Regulation. He also pointed out that it is by no means uncommon for specialist officers employed by a Colonial Government to undertake, for remuneration, lectures at a university or college in the territory and to serve as external examiners. The official view is that in general the regulations are interpreted reasonably from the point of view of both scientific and other officers and of the Colonial Governments; but the Secretary of State has undertaken to inquire into any particular case where it is considered that an unduly strict interpretation of the relevant Colonial regulations has been adopted.

Co-operation between the Cape and Radcliffe Observatories

All interested in astronomical observations will welcome the adoption of a scheme for co-operation between the British observatories in South Africa. By payment of an annual sum to the Radcliffe Trustees, the Cape Observatory will secure the use of the 74-in. reflector at Pretoria for a third of the observing time. As is well known, the funds available for the Radcliffe Observatory suffice for the employment of only three astronomers—not nearly enough to make full use of the telescope, which is the largest in the southern hemisphere. The additional sum made available will enable the Observatory to engage a mechanic-night assistant and a secretary-librarian, and so take a burden off the scientific staff. What money is left over will be used for improving the subsidiary equipment and buildings. At the same time, the Cape Observatory will be enabled to extend its researches; for although it has many instruments, they have only moderate light grasp and most of them are fifty or more years old. The Cape Observatory has no reflecting telescope. For the last few years the Cape astronomers have had occasional use of the 74-in. reflector through the courtesy of the Radcliffe Observer, and they can appreciate the possibilities of the new arrangement. Astronomers are only too well aware of the exasperating delays which almost always take place between the planning of a telescope and bringing it into use, and the fact that the 74-in. reflector is already in operation is a point of no small importance.

The Elliott Journal

In 1800 William Elliott set up in business as a maker of scientific apparatus, and for a hundred and fifty years the firm, now Elliott Brothers (London), Ltd., has been associated with instrument making. It is appropriate that the achievements of this firm, its history and the work it is doing should be made known as widely as possible. We therefore welcome the first number of *The Elliott Journal*, admittedly a house journal but one which will be read with interest by many not immediately associated with the firm. The *Journal* is to be published half-yearly and its aim is to give a periodical review of developments in engineering and physical science with particular reference to the work of Elliott Bros. The first number contains a brief foreword by Sir Ben Lockspeiser; a summary of the history of the firm since its foundation; and eight illustrated articles. These discuss the following topics: magnetic amplifiers and their application to industrial purposes; pulsed circuits for resistance strain-gauges; application of the force-balance principle to pneumatic instruments for process control; a photo-electric curve follower; precision A.C. measurement with a D.C./A.C. comparator; a phase-front plotter for testing micro-wave aerials; a precision sine–cosine potentiometer; and thermal fluctuation of charge in linear circuits.

Mycopathologia et Mycologia Applicata

The appearance of the first fascicule of Vol. 5 of the journal *Mycopathologia* under the enlarged title *Mycopathologia et Mycologia Applicata* indicates the wider range that has now been assumed by the journal with the inclusion of more general papers on applied mycology. As the former title suggests, *Mycopathologia* has for several years been the chief world repository for papers on medical mycology. The development of this subject must, indeed, have owed a good deal to the journal, for medical applications of mycology are now known in areas where human fungus diseases were largely unsuspected. Mycological pathology will, indeed, still be represented strongly. The present issue includes, *inter alia*, studies of antidotal properties of various fungi, against the staphylococcus toxin, by Anna Maria Villa; a detailed paper on vitamin deficiencies of pathogenic fungi, by A. E. de Arêa Leão and Amadeu Cury; a critical survey of mycological literature between 1939 and 1942 (Tibor Benedek); and a description of the fungistatic activities of vitamin K on dermatophytes, by A. E. Arêa Leão and Adolpho da Rocha Furtado. Typical of the wider scope is a paper on the enzymatic grouping of bacteria, by Costantino Gosini. *Mycopathologia et Mycologia Applicata* is published by Dr. W. Junk, of 13 Van Stolkweg, The Hague, Netherlands, and the present number is priced at 40 guilders, or £3 15*s*. 4*d*.

Research in the University of Birmingham

The Joint Standing Committee for Research of the University of Birmingham has issued in its

twenty-first annual report a very convenient general survey of research completed and in progress during the academic year 1949–50. The departmental summaries are accompanied, as in the previous report, by particulars of theses approved for higher degrees and by lists of published work for the academic year 1949–50 which can be regarded as contributions to original knowledge. The whole presents a concise but impressive picture of the contribution coming from the University of Birmingham, and its value would be only enhanced if all universities followed this example. The increasing dependence of universities upon the State for financial assistance makes such reports a desirable, as well as a reasonable, complement to the reports coming from the University Grants Committee itself.

Personnel Management

In a recent issue of the *Journal of the Institute of Personnel Management* (33, No. 314; March–April 1951), the personnel officer in a large industrial organization puts forward constructive proposals why the 'closed shop' policy in industry should be accepted. In reply, other personnel officers suggest that to make membership of a trade union a condition of employment in any firm is an unwarrantable interference with the liberty of the individual. Among other articles in the *Journal* is one by Miss Helen Baker, the associate director of the industrial relations section at Princeton University, giving her views on joint consultative practice in British industry, a report on promotion policy in nationalized industries prepared by the Acton Society Trust, and an account of the training of new entrants for the Westminster Bank by L. C. P. Cann.

Penicillin Formation in Pea Juice

Popular interest in penicillin is matched by concentrated research to find more about the mechanism of its production. Dr. R. P. Cook and Dr. Margaret B. Brown have studied the production of penicillin on media containing juice of the pea (*Pisum sativum*) and compared it with that from media of known chemical composition (*Proc. Roy. Soc. Edinburgh*, B, 64, Part 2, No. 6; 1950). High yields of penicillin were obtained with one fraction of the pea juice, obtained by adding ethanol to the extract. The chemical composition of this fraction is complex; but the chief constituents have been determined. Other experiments with chemically defined media suggest that the highest yields of penicillin have been obtained only in the presence of a complex mixture of nitrogen-containing compounds. Excess of carbohydrates such as glucose caused an increase in growth but a rapid decrease in the production of penicillin. The Peoria strain 1249 *B*21 of *Penicillium notatum* was used in these experiments.

Correspondence of Lavoisier

Dr. Douglas McKie, University College, Gower Street, London, W.C.1, writes: "In 1948 the Academy of Sciences of Paris appointed a committee for the editing and publication of the correspondence of Antoine Lavoisier (1743–94), the great French chemist. A preliminary catalogue of all letters and documents so far traced in France was compiled by the secretary of the committee, Prof. René Fric, of the University of Clermont-Ferrand; and copies were distributed in 1949 to many libraries throughout the world with the request for further information, as a result of which many important items were located. As there may be others still untraced in Great Britain, I would be grateful to librarians and private owners for information of any such letters or documents in their care or possession."

Royal Statistical Society: Officers

At the annual general meeting of the Royal Statistical Society the following elections were announced: *President*, Prof. Bradford Hill; *Honorary Secretaries*, Mr. R. F. George, Mr. Richard Stone, Mr. Philip Lyle; *Honorary Treasurer*, Mr. R. F. Fowler. Mr. F. A. A. Menzler, president of the Institute of Actuaries, was awarded the Society's Guy Medal in silver.

Announcements

Prof. E. Guyenot, professor of zoology and comparative anatomy in the University of Geneva, has been elected a non-resident member of the Paris Academy of Sciences in succession to the late Prof. L. Cuénot.

Dr. Lillian M. Gilbreth, president of Gilbreth Incorporated and a member of the board of directors of the American Management Council, has been elected an honorary fellow of the British Institute of Management. This is the first occasion on which the Institute has made such an election.

'Open Days' at the Chemical Research Laboratory, Teddington (Department of Scientific and Industrial Research), have been arranged for September 19 (afternoon), September 20 (morning), September 21 (morning or afternoon). Applications to attend should reach the Director before August 31; firms already on the invitation list need not apply.

The forty-seventh Autumn Foray of the British Mycological Society will be held at Hereford during September 12–19, with headquarters at the Training College, Hereford, at which accommodation will be available. Those wishing to attend should notify the secretary, Dr. C. J. Hickman, Department of Botany, University, Birmingham 15, not later than August 11.

The Faraday Society, on the invitation of the National Research Council of Canada and various Canadian industries, will hold a general discussion meeting at the University of Toronto in September 1952. The subject will be "The Reactivity of Free Radicals". In addition, visits to various universities and industrial concerns are being planned. Those interested should communicate as soon as possible with the Secretary of the Faraday Society, 6 Gray's Inn Square, London, W.C.1.

A "Name Index of Organic Reactions", by Prof. T. S. Wheeler and J. E. Gowan, published by the Society of Chemical Industry (56 Victoria Street, London, S.W.1; pp. 46; 5*s*. net), gives briefly the nature of various reactions named after their discoverers, and should be useful to students of organic chemistry and others who may not recall what a particular reaction denotes. There are references to literature.

Erratum. In the communication "Vitamin B_{12} Content of Soft- and Hard-shell Clams" (*Nature*, July 7, p. 36), the organism mentioned in paragraph 3 is *Lactobacillus leichmannii*; in the last line of the same paragraph, for "0·4 μgm." read "0·5 mμgm.".

HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA AND SOUTH-EAST ASIA

THE history of the sciences, pure and applied, in India and other parts of South Asia, still remains the greatest 'unknown continent' in this world of study, so important for the general cultural history of mankind. It was therefore an excellent idea to gather together in November 1950 a group of Indian and South Asian scholars interested in the history of science, and to publish, even if only in a provisional form*, the papers which were read to the symposium. The result shows clearly that there is an enormous amount of material already available for the work of synthesis, in which we must attempt to place the development of science and scientific thought in India in its proper framework of parallel developments, some later, some earlier, in Europe and in other parts of Asia. It is also clear, however, from the papers in this symposium, that the task is perhaps the most difficult of all those which face historians of science to-day, owing to the extreme uncertainties in the dating of the most important texts, and even of actual objects which have survived.

Some of the papers, such as the general surveys given by A. S. Altekar and by R. C. Majumdar, are judicious and careful concerning this, and will no doubt be in greatest demand if copies are available separately. Some of the specialized papers (such as that by B. L. Raina) are also reasonably cautious. Unfortunately, this cannot be said of the majority of the papers, which put forward quite unacceptably early datings especially for texts purporting to date from the first two millennia B.C.; particularly bad examples are the two papers on astronomy (by Shukla and Dixit) as well as others on chemistry (by N. R. Dhar), embryology (R. V. Seshaiya) and medicine (G. V. Satyanarayanamurthi). The accompanying table shows the divergence of opinion. It is even maintained that the Babylonians owed the sexagesimal division of the circle and the system of twenty-eight lunar mansions to India. In general, we find throughout the papers too marked a chauvinistic tendency, an effort to minimize foreign influences on Indian science and to emphasize all outward transmissions—this is, of course, all too easy so long as Indian history has not been provided with a strict chronology. Typical of the desire to make a case is the praise bestowed upon the potters of the Mohenjodaro civilization (P. Ray), where no comparison is made with other pottery products studied by the author, nor is any ceramics expert cited whose opinion might carry weight. Along with these tendencies goes the fault of trying to read too much into ancient texts, as when the Pillar Edicts of Asoka or the text of the "Arthashastra" are appealed to as evidence for advanced fishery legislation (S. L. Hora); here the writer is roundly taken to task by a colleague (R. C. Majumdar). But great uncertainty seems to reign, for the sceptic himself seems to be perhaps too sceptical regarding the military use of arsenical smokes—which were certainly developed quite early by the Chinese. So while most of the writers are too rash, others are too modest, notably the writer on Siam (P. Rochanapurananda), who disclaims any contribution of his own Thai people to science, failing to mention the work of la Loubère* in the seventeenth century, which shows that Europeans were at that time much interested in what the Siamese knew. Even if this turned out to be mostly Chinese—as it did—Siam must certainly have had something to show in fields such as textile technology. The same applies to the paper on Indonesian culture (Prijohutomo).

Until the problem of the dating of Indian texts is solved, all those of transmission must remain impossible to deal with. Hence the confidence shown by papers such as that on Indian–Chinese relations (P. C. Bagchi) is entirely misplaced. We cannot admit the derivation of the Chinese lunar mansions from India (probably both systems are ultimately Babylonian). It is absurd to claim Indian influence on a mathematical work such as the "Sun Tzu Suan Ching" (third century A.D.) on the ground that the word 'Ching' was afterwards used for translating the term 'Sutra' in Buddhist texts—all canonical books were known as 'Ching' from the time of the Warring States (fourth century B.C.). Nor is there any mention in this paper of the numerous cases which have been noted of the reappearance of Chinese mathematical problems in subsequent Indian texts.

Nevertheless, the study of the history of science in India remains enthralling. The following words of Filliozat, in the preface to his recent splendid monograph on the theories of classical Indian medicine†, are well worth pondering:

"Some may doubt the legitimacy of placing Indian and Greek science on the same level, preferring to compare the former rather with that of Islam. The common opinion that Indian science lacked originality presupposes that it was derived from Greek science, and is therefore sister to the science of the Arabs. . . .

"This problem has been far too much prejudged. Indian scholars, moved by national pride, are prone to maintain that their sciences in high antiquity surpassed even those of to-day. In the West, on the other hand, many maintain that the spirit of scientific research could only have been born in Europe, and that what science the Indians had they borrowed. In either case the only proofs presented are a few examples claimed as characteristic and used as the basis for generalizations, hypotheses taking the place of facts which are still undiscovered or which people will not take the trouble to seek. Indeed, opinions rest on racial or national preconceptions rather than on a profound comparative study of the two great scientific traditions the value of which is to be determined. One notes also that those who speak with the greatest certainty in these matters are just those who are familiar with only one of the two traditions, knowing the other only by scattered facts, or studies which they are unable to appreciate. To say nothing, of course, of those 'authorities' who know nothing of either of the two traditions about which they speak.

* Proceedings of a Symposium on the History of Science and Technology in South Asia, Delhi, Nov. 1950. Organized by Unesco, and obtainable in mimeographed form from the Unesco Field Science Cooperation Office, c/o University of Delhi. About 150 pp., mostly single-spacing, mimeographed foolscap-size typescript.

* "A New Historical Relation of the Kingdom of Siam . . .", tr. A. P. Gent, F.R.S., from the French edition of 1691 (London, 1693).

† Filliozat, J., "La Doctrine Classique de la Médecine Indienne", Imp. Nat. (CNRS and Geuthner, Paris, 1949).

DATING OF INDIAN TEXTS

	Dating accepted by critical modern scholarship (and in papers by A. S. Altekar and R. C. Majumdar)	Papers by K. R. Dixit and G. V. Satyanarayanamurthi	Paper by K. S. Shukla	Papers by P. Ray, S. L. Hora and R. V. Seshaiya
Vedic material	*c.* −14th (−1400/−1000)	−6000/−1500	−4000/−2000	
Upanishads period	−10th to −6th	−17th/−7th		−2500/−2000
Calendrical texts: "Jyotisha Vedanga",	−600/−200		−1400	
"Surya Prajnapti"	*c.* −400		−500	
Astronomical text: "Surya Siddhanta"	+4th or +5th		±0	
Economic and technological text: "Arthashastra"	−1st			−4th
Medical and biological texts: "Susruta Samhita",	−1st (present text +11th)	−7th		−6th
"Charaka Samhita"	+1st (present text +8th)	−7th		−6th

"The greatest historians of science have not always escaped from the inconvenience of knowing only one side of the matter. Paul Tannery, so famous for his studies on ancient mathematics, is an example. We know that the trigonometric sine is not mentioned by Greek mathematicians and astronomers, that it was used in India from the Gupta period onwards (+3rd. century), that the *Surya Siddhanta* (+4th. or +5th. century) gives a table of sines, that the Arab astronomers knew them from their Indian contacts and passed them on to Europe in the +12th. century, when the work of al-Battani was translated into Latin. The only conclusion possible is that the use of sines was an Indian development and not a Greek one. But Tannery, persuaded that the Indians could not have made any mathematical inventions, preferred to assume that the sine was a Greek idea not adopted by Hipparchus, who gave only a table of chords. For Tannery, the fact that the Indians knew of sines was sufficient proof that they must have heard about them from the Greeks.

"If this is the way we are to argue, there was never any science other than Greek science, and the question whether science has any origins other than the Greek 'miracle' is solved in advance. Only a profound study of Indian scientific developments in parallel with those which took place elsewhere about the same times, can reveal the degree of originality of that science, and hence enable us to understand the rôle which India played in the history of the growth of man's knowledge of Nature."

In the present symposium, the writer on Siam ends, somewhat pathetically: "At present we all seem to believe that science is something which originated especially in Europe and the Near East, and that the Far East had no share in the building of this most important branch of human knowledge. Yet Asian countries such as India and China were important centres of culture both materially and spiritually. Their peoples had learned how to control the natural world around them, and to live a life in which there was room for leisure, only it seems that the knowledge gained by them never joined up with what we know today as modern science. However, Asian people now find no difficulty in learning science and do not lack ability in scientific research."

In my opinion, future research on the history of science and technology in Asia will, in fact, reveal that the achievements of these peoples contributed far more, in all pre-Renaissance periods, to the development of world science than has yet been realized. The programme of Filliozat is the answer to the perplexity of Rochanapurananda.

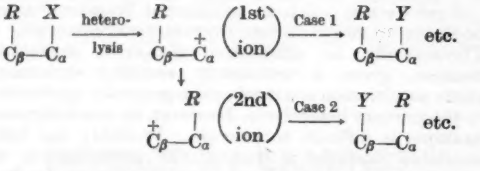
JOSEPH NEEDHAM

WAGNER CHANGES, SYNARTETIC ACCELERATION AND SYNARTETIC IONS

By F. BROWN, PROF. E. D. HUGHES, F.R.S., PROF. C. K. INGOLD, F.R.S., and J. F. SMITH

University College, London, W.C.1

IT has been established[1] that the Wagner rearrangement is a form of unimolecular nucleophilic substitution or elimination (S_N1, $E1$); its primary step is that of all such unimolecular reactions, namely, a heterolysis with the production of a carbonium ion. Let us, for present convenience, call the obvious structure for this ion that of the 'first' carbonium ion. This ion might simply take up an anion (S_N1 substitution), or lose a proton ($E1$ elimination). However, the characteristic phenomenon of a Wagner change is that, prior to any such occurrence, a carbon atom with its full octet shifts over from an adjoining position to the charge-centre of the first ion. If nothing else happened, this would produce what we might call the 'second' carbonium ion. It is from this that the rearranged products may be considered as derived, either by uptake of the originally separating anion (Wagner isomerization), or by uptake of a different anion (Wagner substitution), or by loss of a proton (Wagner elimination):



As shown earlier[2], some primary heterolyses are 'accelerated'; that is, they occur much more rapidly than when the bond undergoing fission has the same local surroundings in simpler molecules; some heterolyses are not accelerated. Also, some heterolyses involve Wagner rearrangements, and some do not. The relationship between incidence of acceleration and of the Wagner change requires analysis.

One possible mechanism for the acceleration of a primary heterolysis depends on the release, during the process, of initially stored non-bonding energy: this has been defined[2] as 'steric acceleration'. Obviously it might operate whether a Wagner change is involved or not. Another mechanism of accelera-

tion, which could evidently operate when a Wagner rearrangement is involved, would gain the excess rate from a release of bonding energy during the bond-shift characteristic of the Wagner change: this we shall call 'synartetic acceleration', for a reason that will become clear later. We shall also note later, what is not immediately obvious, namely, that this mode of acceleration may operate even when a Wagner change is not involved. The ranges of incidence of the two accelerative mechanisms require consideration.

We have approached the two problems stated by trying experimentally to answer a number of simple guiding questions by the provision of examples. One might first ask: Can acceleration ever arise without a Wagner change? The following example shows that it can. The rate of hydrolysis of camphene-hydrochloride in aqueous solvents to camphene-hydrate and camphene is too great to be easily measured; it is obviously greater than the corresponding rate for simple tertiary alkyl chlorides. The rate of the analogous unimolecular ethyl-alcoholysis has been measured[3] (for example, $k_1 = 4{\cdot}0 \times 10^{-5}$ sec.$^{-1}$ at 0° in dry ethyl alcohol), and has been found to be about 6,000 times greater than the corresponding rate for *tert.*-butyl chloride.

The next question is complementary: Can a Wagner rearrangement ever occur without acceleration? Again the answer is affirmative. The unimolecular solvolysis of *neo*pentyl bromide[4], to give exclusively Wagner-rearranged *tert.*-amyl alcohol or *tert.*-amyl alkyl ethers and *iso*amylenes, takes place at rates ($k_1 = 1{\cdot}53 \times 10^{-6}$ sec.$^{-1}$, for hydrolysis at 95° in wet formic acid) which are of the same order of magnitude as those of the corresponding solvolytic reactions of ethyl bromide ($k_1 = 2{\cdot}70 \times 10^{-6}$ sec.$^{-1}$ in the same conditions). The unimolecular solvolysis of pinacolyl chloride, again to give exclusively Wagner-rearranged products, takes place at rates ($k_1 = 1{\cdot}94 \times 10^{-7}$ sec.$^{-1}$ in 80 per cent aqueous ethyl alcohol at 80°) which are of the same order as those estimated for the unimolecular solvolysis of *iso*propyl chloride ($k_1 \sim 5 \times 10^{-7}$ sec.$^{-1}$ in the same conditions)[5]. A similar comparison could be given of pinacolyl iodide and *iso*propyl iodide[6].

These two types of examples show that the boundaries of the areas of incidence of acceleration and of Wagner rearrangements intersect.

Next we ask: Can an accelerated Wagner change be shown to derive its rate from 'steric acceleration'? Theoretically, an affirmative answer is expected, because, given a sufficiently ramified structure, steric acceleration is a mechanism generally applicable to the primary heterolysis. However, an unambiguous example is difficult to provide. Probably the best available example is that of the isomerization of camphene-hydrochloride in aprotic solvents to *iso*-bornyl chloride. It has been found[7] that chlorine exchange between camphene-hydrochloride and chloride ions takes place more rapidly than the isomerization, which is not catalysed by chloride ions; and the conclusion has been drawn[8] that the heterolysis essentially precedes the Wagner rearrangement, which occurs during one of two competing forms of ionic reassociation. Now the initial heterolysis is identical, apart from the solvent difference, with the initial stage of the solvolysis of camphene-hydrochloride, which, as noted above, is strongly accelerated, but involves no Wagner change. Hence the acceleration could be a 'steric acceleration'. But even here, as we shall see later, 'synartetic acceleration' is not excluded. However, having regard to the structure, and the large magnitude of the observed effect, we incline to the view that both mechanisms make substantial contributions.

The complementary question is: Can an accelerated Wagner change be shown to derive its rate from 'synartetic acceleration'? Here the answer is definitely affirmative. As indicated in an earlier communication[9], tritylmethyl chloride, like *neo*pentyl chloride, is incapable of easy bimolecular reactions; and hence its unimolecular reactions, which give exclusively Wagner-rearranged products, may be studied, not only in formic acid, but also in aqueous alcoholic solvents. Charlton, Dostrovsky and Hughes found[9] that in formic acid it was hydrolysed by water at a rate ($k_1 = 2{\cdot}3 \times 10^{-3}$ sec.$^{-1}$ at 95°) estimated as about 50,000 times that for *neo*pentyl chloride. Comparisons referring to aqueous alcoholic solvents gave similarly large ratios. We assume that steric acceleration could not apply to the ionization of a primary halide, and that therefore synartetic acceleration is here responsible.

The following example[3] is especially instructive. First, the unimolecular solvolysis of bornyl chloride, to yield Wagner-rearranged products of the camphene series, takes place at rates ($k_1 \sim 1{\cdot}5 \times 10^{-7}$ sec.$^{-1}$ extrapolated for 80°, in 80 per cent aqueous ethyl alcohol) which are of the same order as those of the solvolysis of pinacolyl chloride ($k_1 = 1{\cdot}94 \times 10^{-7}$ sec.$^{-1}$ in the same conditions). Secondly, the solvolysis of *iso*bornyl chloride, also to give rearranged products, has rates ($k_1 \sim 1{\cdot}4 \times 10^{-2}$ sec.$^{-1}$ as above) which are about 70,000 times those of pinacolyl chloride. Steric acceleration seems here to be excluded, because *iso*bornyl chloride, the *exo*-isomeride, can scarcely be supposed to have *more* non-bonding energy than bornyl chloride, the *endo*-compound: again we conclude that synartetic acceleration is responsible. Moreover, it neatly interprets the stereo-kinetic distinction. For in the *exo*-structure, a Wagner-type bond-shift could be initiated before the ionizing chlorine atom has attained the separation of the transition state of ionization (that is, before the chlorine atom has moved by more than about 0·4 A.); and therefore the initiation of the bond-shift could kinetically influence the heterolysis. But in the *endo*-structure, no such bond-shift could commence until the chlorine atom has passed out of the

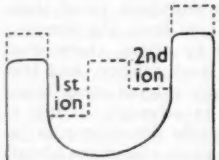


Fig. 1

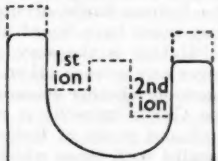


Fig. 2

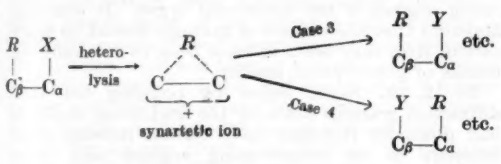
(The reaction path enters from the left and leaves over whichever transition state lies lower, that is, by the left in Fig. 1 and by the right in Fig. 2)

Case 1, *nN* (broken line). Non-rearranging $S_N1/E1$ without synartetic acceleration (for example, solvolysis of *tert.*-amyl bromide).
Case, 3, *aN* (full line). Synartetically accelerated non-rearranging $S_N1/E1$ (for example, solvolysis of camphene-hydrochloride).
Case 2, *nW* (broken line). Wagner rearrangement, without synartetic acceleration (for example, solvolysis of *neo*-pentyl bromide).
Case 4, *aW* (full line). Synartetically accelerated Wagner rearrangement (for example, solvolysis of *iso*-bornyl chloride).

way (that is, to well beyond the transition-state distance); and thus the shift could here have no kinetic influence.

While recognizing that marginal situations arise, we can divide the reactions discussed into four main classes, as illustrated by the schematic energy-reaction curves of Figs. 1 and 2. In unaccelerated unimolecular reactions, whether or not they involve a Wagner rearrangement, the 'first ion', and the transition state of its formation, are unaffected by the existence, or possibility of existence, of the 'second ion'. We assume that in unaccelerated Wagner changes there must be two ions; but that when, in unaccelerated reactions, there are two, they are separated by an energy barrier substantial enough to preclude their energetically significant interaction. So we have either (case 1, nN) (the letters mean 'normal rate, normal structure') non-rearranging unimolecular reactions without synartetic acceleration (Fig. 1, broken line), or (case 2, nW) ('normal rate, Wagner change') Wagner rearrangements without such acceleration (Fig. 2, broken line), according as the transition state of the heterolysis which forms the 'first ion' lies energetically lower or higher than that of the co-ordination which destroys or would destroy the 'second ion'.

The other two classes can be most simply described by assuming that there is no resonance-stopping barrier between the first and second ionic structures, which interact according to a suggestion[10] made earlier, to produce a normal ion more stable than either—a *synartetic ion*, as we may call it, with a split single bond *fastening together* the locations of a split ionic charge. We then have not only a stabilized ion, but also stabilized transition states of ionization, and therefore either (case 3, aN) ('accelerated, normal structure') non-rearranging unimolecular reactions with synartetic acceleration (Fig. 1, full line), or (case 4, aW) ('accelerated, Wagner change') Wagner rearrangements with such acceleration (Fig. 2, full line), according, as before, to which of the two transition states lies lower. For these cases, we should modify our previous formulation:



Marginal cases (between 1 and 3, and between 2 and 4) should arise when a tunnel effect permits weak resonance between the first and second ions; but we shall not now discuss this phenomenon. Marginal cases of another sort (between 1 and 2, and between 3 and 4) arise when the two transition states lie on a common energy-level, so that the diagrams of Figs. 1 and 2 become symmetrical, as in Fig. 3. This happens when the unrearranged and Wagner-rearranged products are identical, but for some non-energetic distinction, as when they are enantiomeric, or are labelled isotopically. We then have either (border-case 12, nNW) reactions without synartetic accelerations (Fig. 3, broken line), or (border case 34, aNW) reactions with synartetic acceleration, leading, in either case, to 50 per cent of Wagner-rearranged product (for example, to racemization when the optical distinction is employed). A normal-rate

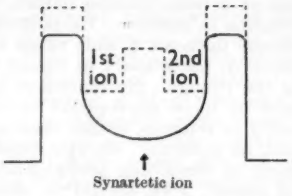


Fig. 3

(The reaction path enters from the left, then divides, and leaves equally by the left and by the right)
Border cases 1, 2 (broken line) and 3, 4 (full line)

reaction having the described symmetry (border case 12) has been found by Cram[11] in the solvolysis with racemization (at both asymmetric centres) of that form of 2-phenyl-3-*n*-butyl *p*-toluenesulphonate for which the normal and rearranged substitution products would be enantiomers.

One usually thinks of CC-bond σ-electrons as having a much smaller tendency to enter into other orbitals than have CH-bond σ-electrons, or of course π-bond-electrons or unshared *p*-electrons. Yet it appears that CC-bond σ-electrons can interact strongly with a carbonium ionic centre to form what we have called a synartetic ion, at least when the stereoelectronic situation is favourable, and when the normal types of conjugation and hyperconjugation are more or less restricted. This seems somewhat less strange when we recall that the carbonium ion has the same electron configuration as the tercovalent boron atom, and that it is one of the lessons of boron chemistry that all low-lying orbitals will somehow achieve partial occupation, even when there are too few electrons to occupy them fully (this was recently pointed out to us by Dr. S. H. Bauer): the same principle may apply in carbonium ion chemistry.

[Feb. 2.

[1] Dostrovsky, Hughes and Ingold, *J. Chem. Soc.*, 192 (1946).
[2] Brown, Davies, Dostrovsky, Evans and Hughes, *Nature*, [**167**, 987 (1951)].
[3] Results of present authors.
[4] Dostrovsky and Hughes, *J. Chem. Soc.*, **164**, 166, 171 (1946).
[5] Martin, thesis (London, 1949); *Nature*, **166**, 679 (1950).
[6] Unpublished experiments by Mrs. M. G. Peeling.
[7] Nevell, de Salas and Wilson, *J. Chem. Soc.*, 1188 (1939).
[8] Bateman, Cooper, Hughes and Ingold, *J. Chem. Soc.*, 930 (1940).
[9] Charlton, Dostrovsky and Hughes, *Nature*, [**167**, 986 (1951)].
[10] Ingold, cited by Watson, *Ann. Rep. Chem. Soc.*, **36**, 197 (1939), and "Modern Theories of Organic Chemistry", Oxford Press, 2nd Ed., p. 208 (1941); also by Simonsen and Owen, "The Terpenes", Cambridge Press, 2nd Ed., p. 161 (1949).
[11] Cram, *J. Amer. Chem. Soc.*, **71**, 3836 (1949).

DIFFRACTION GRATINGS

THE Optical Group of the Physical Society held a symposium on diffraction gratings at the Imperial College of Science and Technology, London, on May 10. About seventy-six members and visitors attended and the meeting was generally very successful. A large number of exhibits and demonstrations illustrating the ruling and testing of gratings was shown.

Prof. W. E. Curtis, in introducing the subject, surveyed the present field of application of the grating and indicated the directions in which development is desirable. He mentioned a variety of problems in both atomic and molecular spectroscopy, for which gratings are required, in addition to spectrochemical

investigations of a more routine nature, which are steadily increasing in number. He pointed out that for these various purposes a wide range of gratings would be required, particularly in regard to spacing and form of the rulings. He remarked, in passing, that it would be more appropriate to specify the spacing directly in microns, rather than as so many lines per inch, as hitherto. He also urged that the present custom of describing performance in terms of 'resolving power', $\lambda/\delta\lambda$, should be abandoned as neither physically significant nor practically convenient, and replaced by a statement of the limit of resolution (based on the Rayleigh criterion) in cm.$^{-1}$. This has the advantage of depending only on the ruled width of the grating and its setting, and not on the spacing or the spectral region. Its minimum value would be the reciprocal of twice the grating width, as in the reflecting echelon. The optimum spacing in a particular case would be determined by other considerations, such as the overlapping of neighbouring orders and the extent to which groove shape could be controlled.

Prof. Curtis then referred to some special modifications which may prove valuable in the future, notably the Harrison echelle grating. This has yet to prove itself, but certainly appears very promising. The combination of grating and mirror in Littrow fashion, as proposed by Hulthén and Lind, may well prove valuable in certain circumstances. He remarked also that the introduction of the photomultiplier renders a plane-grating – concave-mirror spectrograph an attractive proposition by reason of its simplicity of construction and adjustment.

So far as ordinary gratings are concerned, Prof. Curtis considers that there are four main directions in which improvement should be sought: the elimination of ghosts, either by perfecting the traditional ruling-method or by developing entirely new ones; the concentration of light in a given direction by control of groove form; the provision of larger gratings, although a greater ruled width only would suffice for some purposes; and finally, a substantial reduction in cost, so that a spectroscopist can acquire a number of gratings from which he may select the one best suited to each problem. Having regard to the effort already expended on the ruling of gratings, it might seem that only limited progress along these lines would be possible; but modern advances in technique and materials are such as to give good grounds for optimism.

Speaking of the history of the diffraction grating, J. S. Clark said that it originated in the pioneer work of Joseph Fraunhofer early in the nineteenth century. Reference was made to Nobert, of Barth in Germany (1850), and to Rutherford in the United States (1875), who was the first to rule a reflexion grating on speculum metal. The ruling of gratings at Johns Hopkins University, Baltimore, was initiated by Rowland in 1880 and continued by Anderson (1909), Wood (1923) and Strong. Other grating-ruling engines established in the United States were those of Michelson (1900) and Gale (University of Chicago) and those of Anderson (1916) and Babcock (Mount Wilson Observatory).

The Blythswood ruling engine, which has been in the possession of the National Physical Laboratory, Teddington, since 1908, dates from about 1880, when its construction was undertaken by Lord Blythswood with the assistance of Otto Hilger (one of the founders of the firm of Adam Hilger). Its subsequent history was described by Mr. Clark, and brief mention was also made of the ruling engines constructed by Grayson (1893) at Melbourne and by Siegbahn (1930) at Uppsala and at Stockholm. After pointing out that all existing ruling engines of conventional design have been either of the shaper type (for example, Rowland and Blythswood machines) or of the planer type (such as Strong's new machine at Johns Hopkins University), Mr. Clark went on to discuss the future prospects of ruling large gratings by conventional methods and concluded with a fairly detailed description of the Blythswood machine in its present state.

J. Guild described how interference tests, which have long been familiar in their application to the examination of mirrors, prisms, lenses and even complete optical instruments, can be applied to diffraction gratings, and stressed the fundamental importance of these tests in assessing the optical performance of gratings and indicating the nature, magnitude and location on the grating surface of the defects of figure or errors of ruling responsible for defects of performance.

The tests described were an adaptation of the well-known Fizeau test for plane mirrors to plane reflecting gratings: an adaptation of the differential interference (sheared wave-front) test developed by Ronchi and Bates for concave mirrors to either concave or plane gratings; and a test depending on the interference between the wave-fronts diffracted by a superposed pair of transparent replicas of a plane grating. For the second test Mr. Guild employed a simple beam-dividing device based on the Wollaston or Rochon double-image prism. This is free from some of the defects of Ronchi's apparatus and, while possessing all the flexibility required for the present purpose, is much simpler and less costly than the wave-front shearing interferometer of Bates. Slides were shown of interferograms obtained by each of these methods, those illustrating the first two being of gratings ruled on the Blythswood, Rowland and Siegbahn engines.

It was clear from those examples that, judged by ordinary optical standards, there is plenty of room for improvement in the best gratings produced by ruling engines of the traditional types. It was also apparent that the makers of gratings should be more careful than they seem to have been to rule only on blanks of good optical quality.

Dr. L. A. Sayce began by pointing out that diffraction gratings made by the traditional methods laid down by Rowland have certain defects, some inherent in all reciprocating engines and some attributable to the residual errors of screws, division plates, thrust bearings and the like. There is therefore special interest in a new approach to the problem suggested by Sir Thomas Merton which is being developed in the National Physical Laboratory by the Light and Metrology Divisions. Dr. Sayce explained that the fundamental concept is to rule diffraction gratings upon cylinders. Such helical gratings can be used directly in conjunction with cylindrical lenses or mirrors, but can more conveniently be used as matrices for the preparation of plane replicas of which many identical 'copies' can be made from each original ruling.

Using this principle, therefore, the production of a plane grating now consists of three main stages. In the first, a screw of up to 15,000 threads per inch is cut upon one-half of a metal cylinder using a suitably modified lathe. In the second, this lathe-cut thread is copied upon the other half of the cylinder

using a 'Merton nut' to remove its inevitable periodic errors. In the third stage, the corrected helix is covered with a thin layer of plastic which, when hardened and annealed, is removed from the cylinder and opened out upon an optically flat surface of swollen gelatine. When the whole has dried, the plastic 'pellicle' can be removed, and the underlying gelatine is found to be moulded into a flat replica of the corrected helix and can be hardened and aluminized.

It was shown by means of specimens and interferograms that these methods have already produced satisfactory gratings, particularly for work in the infra-red, and there seems every reason to hope that they will in due course yield large ghost-free gratings suitable also for emission spectroscopy. As it has been found impossible to devise a method of producing concave gratings from cylindrical matrices, a machine has been developed at the National Physical Laboratory for applying to a reciprocating concave blank a tool advanced by a 'Merton nut' driven by a screw of the pitch of the required grating.

Dr. A. C. Menzies, after referring to some recent work by Messrs. Hilger-Watts on the construction of fine-mesh metallic grids, went on to describe a modification of Sir Thomas Merton's process with the object of producing long gratings. This employs three successive operations. In the first, a short length of fine-pitch thread is engraved on a metal cylinder B by a diamond driven from a 'Merton nut' riding on a similar cylinder A on which a coarse thread has been engraved by a lathe. The two cylinders are connected together by a gear of ratio 32 : 1. In the second stage, a 'Merton nut' on B, with a diamond just ahead of it, extends the fine pitch thread as far as desired along the cylinder. The passage of the nut over the thread which it has ruled tends to produce irregular burnishing of the rulings. Although this would probably have little effect on the performance of a replica taken from the cylinder, it may be eliminated by ruling a third cylinder C by means of a 'Merton nut' riding on B, the two cylinders being coupled together by a 1 : 1 gear. This cannot introduce periodic error, although it may give rise to slight non-linearity of the rulings, which, however, is regularly repeated and therefore not objectionable. In all cases, one end-bearing consists of a 'Merton nut' on a 'neutral' thread, and the other of a similar nut on polished bar. A steel bar ruled by this method for a length of about nine inches was exhibited.

Dr. Menzies also directed attention to the probable value of the 'superfinishing' process, as used by Chryslers in the United States, in much reducing the time required to polish the metal cylinders preparatory to ruling by the Merton method.

In the discussion which followed, F. Twyman emphasized the desirability of comparative testing of existing gratings, especially some of the older ones reputed to be of 'good' quality. Prof. Curtis asked whether any correlation has yet been attempted between the results of the tests described by Mr. Guild and the performance of the grating in an actual spectrograph, to which Mr. Guild replied that this has not yet been possible as sufficient gratings of various qualities have not yet been available. Mr. Guild said that it is his object to establish such a correlation, and added that, although the tests might be capable of disclosing defects which are too slight to affect spectroscopic performance, such additional sensitivity is of great advantage in monitoring the development of the ruling process.

G. Sissen asked Mr. Guild whether it is possible by his wave-front shearing method to alter the inclination of the interfering wave-fronts, and consequently the spacing of the fringes. The latter replied that variation of fringe spacing is effected by displacing the double-image prism along the axis of the instrument. The direction of the fringes is, however, fixed relative to the direction of shear, in which respect Mr. Guild's beam divider is less flexible than that of Bates for general optical testing. Mr. Sissen then asked Dr. Sayce whether the thickness of the gelatine layer in the third stage of his process could be sufficiently increased to produce infra-red gratings, and received the reply that, although an increase in the thickness of the layer causes a slight departure from flatness, this is not enough to be detrimental in the infra-red region.

There was some discussion of the possibilities of the step-by-step method of grating ruling, which is attractive by reason of the elimination of the screw and its attendant errors. Various speakers referred to attempts on these lines, made in Germany, Sweden and Great Britain; but it appears that none has been successful. The fundamental difficulty is thought to be that in any process of this type an accidental error of spacing will necessarily affect the whole of the subsequent rulings.

THE 1951 EXHIBITION OF SCIENCE

THE 1951 Exhibition of Science is splendidly housed, to the south of the Imperial College, in an extension of the Science Museum which is to form the nucleus of new permanent additions to the Museum buildings. A wealth of skill and decorative genius has gone to the making of a display which, despite some minor shortcomings, is an outstandingly good presentation of some of the main developments of pure science during recent years, with some appropriate historical background. It is planned as a continuous narrative (one might almost say a short course) and the round trip takes between one and two hours.

One enters by a maze-like tunnel with sound-proofed bays, in each of which a loud-speaker suggests that one is shrinking to atomic dimensions as illuminated models of graphite crystals expand successively; at the end of the tunnel the visitor is on equal terms with an electron cloud. He is to see modern science from the atomic point of view.

The first stage of the journey around the exhibition itself deals with atomic structure. The diagrams and mural showing the history of the Periodic Table and its modern representation are good. The experiments on the electron are indifferent, chiefly due to lack of explanation as to why electric and magnetic deflexions occur; and some of those listed are missing. There are some excellent animated diagrams illustrating radioactivity and nuclear physics, and two cloud chambers which work beautifully; but why the catalogue should include under radioactivity a spectrometer "capable of refractive index measurements of 0·000001", whatever that may mean, is a mystery.

Next come sections on chemical structure, the nature of chemical bonds, and the structure of metals and crystals. These are on the whole mag-

nificent, lending themselves admirably to representation by the modeller. The exhibits on enzymes are introduced curiously—first by a film-strip of a rugby footballer which is quite irrelevant unless it is intended as a miming for the word 'conversion' (though it is a penalty kick), and then by a model of a dancing class which could not be interpreted; but the exhibits themselves are clear enough.

Associated with the chemical section are a number of poorly adjusted ripple-tank experiments, which do not do justice to a well-known make of apparatus, and which are intended to lead up to the idea of X-ray diffraction by crystals. In this section also is shown the *EM*3 electron microscope. The catalogue says this uses four magnetic lenses; as exhibited, it uses one electric lamp underneath one lantern slide, but nevertheless admonishes the public not to tamper with the controls. Is not a leading make of British electron microscope something to show proudly, in working order, on such an occasion?

In the biological exhibits the emphasis is rather on living matter than on the organism as a whole; here again the modeller has had full scope and has done magnificently.

In the "Stop Press" section, pride of place must go to the exhibit on cosmic rays. This is fully documented, and tells the whole story from the first unaccountable electroscope leak to the most recent photographic plate work. It was worth the visit to see this exhibit alone, and to watch a counter-controlled chamber in action. Less impressive, but none the less excellent, is the smaller section on electrons in crystals, which explains the behaviour of luminescent materials clearly and effectively. Nimrod, the Ferranti electronic computer, is a good demonstration; the game it plays is simple, and any opponent who knows the rules has a good chance of success. The operator says it has a temper; but its face lights up after every move, whether advantageous or otherwise.

Nimrod, in fact, sets a standard by which many of the other 'working' exhibits might be judged. It really is in full working order, and it has someone in charge to explain what it is doing. Further, there is an excellent pamphlet published by Messrs. Ferranti, Ltd.*, which describes how it is constructed and how it works, and gives a little of the mathematical theory of digital computers. This pamphlet did not, however, seem to be available within the exhibition itself, which is a pity. There is a bookstall, at which expensive-looking commemorative jig-saw puzzles and scientific books quite unrelated to the exhibition are displayed; how much it could have contributed to the purpose of the whole if an explanatory pamphlet setting out details of some of the more striking individual exhibits (and moderately priced) had been on sale there! For the official guide-catalogue, useful as it is in explaining the exhibition as a whole, does not say very much that is helpful about individual items and is even confusing in places; in view of the fact that many items are neither clearly numbered nor effectively provided with displayed descriptive matter, this is a little disheartening. It says a great deal for the real quality of what there is on show that this criticism, which must be made, does not diminish one's admiration for the whole.

The writer was one of a small company of appreciative visitors who seemed to be pretty well outnumbered by the attendants. By all accounts, the exhibition has not so far touched the popular imagination, and there may be several reasons for this. It is the academic conversazione on the grand scale, with the exhibits clearly linked by one central idea, the structure of matter. Perhaps this is the reason, for people will pay to be entertained or impressed, but not to be instructed. Its very success in achieving its aims may well limit its popular appeal. Or it may be that an enterprise of this kind takes a long time to become widely known and appreciated, or even found. It is quite possible to emerge from the South Kensington subway, and be inside the exhibition on the history of the Science Museum itself, before realizing that it is not what you were seeking; though, of course, there is some discreet short-range guidance for the reasonably observant.

One feels that there is something of permanent educational value here, and a pleasing creation which would be worth a visit if only to see a scientific exhibition dressed in a Festival gaiety.

G. R. Noakes

* Faster than Thought: the Ferranti Nimrod Digital Computer. Pp. 40. (Hollinwood: Ferranti, Ltd., 1951.) 1s. 6d.

GERMAN SOCIETY FOR ELECTRON MICROSCOPY

THIRD ANNUAL CONFERENCE

THE German Society for Electron Microscopy held its third annual meeting in Hamburg during May 18–20. Although the meeting was convened as a national conference, invitations had been accepted by many foreign men of science, so that the conference took on a certain international flavour. Its success was due not only to the high quality of many of the contributions by German and foreign scientific workers, but just as much to the opportunities it offered to make, or renew, contacts between men and women of many countries.

The work of the conference was opened by H. Ruska with a general lecture on the more recent results of electron microscopy, mainly illustrated by examples taken from the biological and medical field. Stress was laid on combining results obtained by electron microscopy with those obtained by other means.

Only some of the large number of papers read (about seventy) can be mentioned here. Mathematical investigations into the properties of certain magnetic electron lenses were presented by Lenz and by Glaser, and experimental methods for the field determination in magnetic lenses were described by Lenz and by Wolff. A very simple 'electron-optical' bench arrangement, to facilitate experimentation, was shown by Boersch.

Instrument design has been pursued steadily during the last year, and Möllenstedt described a simple way of increasing the specimen penetration in the electrostatic instrument by placing the specimen into a chamber kept at +50 kV. with respect to earth, the gun operating at −50 kV.; a direct switch-over from 50 to 100 kV. can be made. The use of the electron microscope in electron diffraction studies has been extended through the development by Heise of an adaptor for glancing incidence work with the AEG–Zeiss instrument. The design of a

small magnetic microscope built at the University of Munich was described by Kinder; this instrument is very similar to the RCA desk-model. An instrument of unconventional design was described briefly by von Borries. This instrument uses a single permanent magnet with two gaps in the iron circuit, one exciting the objective lens, the other the projector lens, the final image being free of image rotation; the magnification of the projector lens can be varied continuously by an axial movement of the pole piece insert. Further experiments with Boersch's filter method, in which the majority of the inelastically scattered electrons which reduce the image contrast in electron microscopy and in electron diffraction are eliminated, were described by Rang, who used an electrostatic lens to obtain the required critical deceleration.

The usefulness of stereoscopy in the interpretation of complicated structures was demonstrated by Helmcke, who also applied the methods of photogrammetry to a quantitative evaluation of stereograms, and by Grasenick.

The problem of the 'tolerance dose' without specimen destruction was discussed from various aspects. Boersch estimated that hydrogen atoms will always remain invisible; but that carbon atoms might possibly be made visible if the resolving power could be increased sufficiently far. Experimental investigations by König gave a much more pessimistic picture; specific loads of 10^4 to 10^5 Wsec./cm.^{2} at the specimen already lead to a partial breakdown of the more complicated materials. Rang showed that by correct choice of the observation screens optimum conditions regarding specimen load during focusing can be maintained.

Interesting details were given by König of the 'carbon skin' method of obtaining three-dimensional 'replicas' of substances which do not stand the high beam intensities often required in their imaging. The specimen to be coated is placed on the aluminium anode of a glow discharge maintained in benzene vapour of about 1 mm. pressure. The carbon coating formed is later 'hardened' either by subjecting the coated specimen in the electron microscope itself to a high beam current, or by keeping it for some time in a vacuum oven at 400° C. The original specimen can then be dissolved, or evaporated out, leaving the carbon skin intact; this gives a faithful representation of the original, as was proved by stereograms of diatom replicas shown by Helmcke.

Surface structure, phase changes and crystal growth phenomena at elevated temperatures in steel and iron–nickel alloys were demonstrated convincingly by Rathenau, using the emission electron microscope; other applications of electron microscopy to metallurgical problems were discussed by several authors. Grasenick has studied crystal growth in magnesium oxide, and Helwig the formation of zinc and cadmium oxides. Several papers described the structures of activated aluminium oxides. Rang and Schluge, as well as Bernard, and Möllenstedt, showed how the Bragg diffraction lines appearing in many electron micrograms of crystalline materials can be co-ordinated with certain lattice positions.

A number of papers dealt with the methods of preparation of biological material; Kellenberger described a critical study of various methods of preparing *B. coli* for the electron microscope, and Winkler an investigation into the method of fixation which gave closest agreement with the light optical picture. The varying success of the 'freeze-drying' method was discussed by Studer and others. Contributions to the study of collagen and reticulin fibrils were presented. Further papers dealt with the reaction of bacteria to certain treatments (for example, of T.B. bacilli to streptomycin) and other cytological questions, and with the first electron microscopical representations of new material.

Progress in the preparation of thin sections of tissues was reported by several workers. Kellenberger described the design of a new microtome (made by Trüb-Täuber, Zurich), cutting reproducibly to 0·05 micron, and illustrated this by slides of thin sections through nerve fibres of frogs and neuro fibrils. Bretschneider uses a modified C.I.C. microtome; he considers that the problem of thin sectioning is no longer one of microtomes but of the technique of fixation; this he described in detail. (Of eighteen mixtures investigated, a composition of paraffin wax, beeswax and carnauba wax was found most successful.) This talk, too, was illustrated by interesting slides. Bernhard discussed investigations on cancer cells using the thin-sectioning technique; the interpretation of earlier American results, showing virus particles in cancer cells, could not be confirmed, as most virulent cancer cells investigated were free of these bodies. Hence, normal cells were studied, in which several new features were discovered, the function of which is still unexplained. Mölbert and Beyersdorfer also described a new microtome (made by Jung, Heidelberg), and discussed the technique of its use. They found that an after-treatment of the thin sections by an electrical discharge in air of 0·05 mm. mercury pressure made them more resistant to the electron beam.

Many other subjects were discussed, for example, polymerizing methyl methacrylate replicas, investigations on textile fibres, rubbers and plant cells, size measurements of sub-microscopical crystals, fine-grain photographic emulsions and studies of surface contamination phenomena with Müller's point projector microscope.

An exhibition of photographs and of new instruments was held in conjunction with the conference. Besides microscopes, microtomes and vacuum accessories, four electron microscopes were on show. All these instruments were distinguished by a high standard of craftsmanship employed in their manufacture, but they were expensive by our standards. The Philips electron microscope has been exhibited in Great Britain on several recent occasions, and does not, therefore, require any further description; but the AEG–Zeiss electrostatic instrument will not be known to many workers here. This machine uses electrostatic lenses throughout. The need for frequent cleaning of the lenses has been greatly reduced through a built-in 'stigmator', which compensates the astigmatism caused by dirt particles getting into the lenses. Three magnifications can be selected by using the two fixed projector lenses singly or in combination; an additional diffraction lens is provided. Siemens demonstrated two instruments, their standard three-lens type for 100 kV., and a new simplified type for 60 kV. Both types are post-war developments of the original Siemens instrument. Both new instruments employ a revolving projector lens head, which allows any of four projector lenses to be brought quickly into operation. Many other improvements over the old type are incorporated, for example, grease vacuum joints are replaced by rubber seals.

G. LIEBMANN

LETTERS TO THE EDITORS

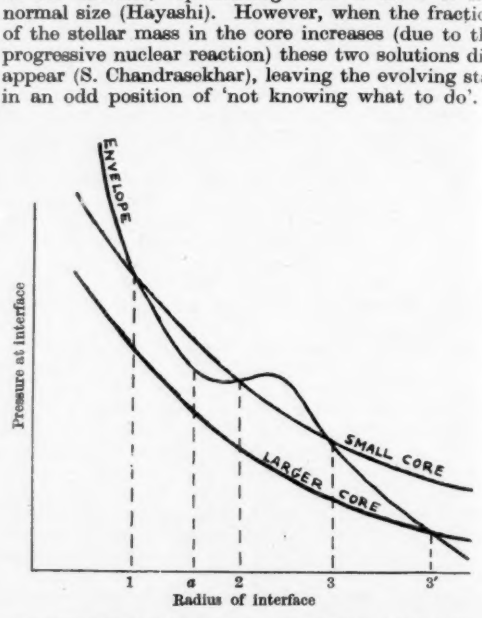
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Hydrogen Exhaustion and Explosions of Stars

It is a well-established fact that energy production in stars is due to the thermonuclear transformation of hydrogen into helium. Since hydrogen forms about one half of normal stellar material, the rate of its consumption, that is, the luminosity of the star, determines the stellar life-span; in the case of our sun it can be calculated to be about fifty thousand million years, which is very long as compared with the estimated age of the stellar universe. Since, however, stellar luminosity (hydrogen consumption) increases very rapidly with stellar mass (hydrogen content), the life-spans of brighter stars are considerably shorter. Thus stars of about zero absolute magnitude would run through their hydrogen evolution in a few thousand million years, that is, in a period of time which is generally accepted as representing the age of our universe. Indeed, we notice that the stars of zero absolute magnitude seem to represent a demarcation line in the stellar population of our galaxy. Thus the main sequence of the Russell–Hertzsprung diagram shows a noticeable discontinuity at that particular point. The brighter stars are very scarce in space and are in a state of rapid axial rotation; the fainter stars are very abundant and scarcely rotate at all. Also, within stellar population II, as defined by Baade (the regions of the galaxy where no interstellar material is present), the upper part of the main sequence is completely absent.

All this suggests that zero absolute magnitude divides the main sequence into the older (lower) part containing the original stock of stars formed almost simultaneously a few thousand million years ago, and the younger (upper) part consisting of stars formed by condensation processes at various more recent epochs. We may also notice that zero absolute magnitude serves as an apex from which the main sequence of stars branches out into 'swollen-up' stellar types such as pulsating variables and red giants in general, and 'shrunken' stellar types which include Wolf–Rayet stars, nuclei of planetary nebula, white dwarfs, and various types of exploding stars (*U*-Geminorum, recurrent novæ, ordinary novæ and supernovæ). It is difficult to escape the impression that stars deviating from the main sequence are those which have run out of their original hydrogen supply, a situation which forces them to go through 'unusual' final stages of their evolutionary life. One would expect, in fact, that all these stars would have comparable masses (at least at the stage when they leave the main sequence) of the order of magnitude of three sun masses and about the same total life-span of a few thousand million years. This conclusion finds support in the Kukarkin–Parenago relation, according to which the intensity of periodic stellar explosions (*U*-Geminorum stars, and recurrent novæ) is directly proportional to the period between explosions. This relation, indicating a constant total rate of energy production, would be difficult to understand for stars of different masses and, consequently, different central temperatures.

If we look at this problem from the point of view of possible stellar models, we find that an ageing star would be expected to develop a so-called 'shell-source' of nuclear energy. In fact, when all the material in Cowling's convective zone supplying fresh fuel for nuclear reactions in the centre is completely dehydrogenized, the reaction would transfer itself into a spherical layer between the isothermal helium core, and the radiative hydrogen-rich envelope. The properties of such shell models have been studied by many authors[1], with rather interesting results. It has been found that an attempt to fit a small isothermal core into a radiative envelope (with the temperature and pressure continuous at the interface) results generally in several possible solutions. One of these gives a star of extremely large radius which can be considered as a tentative model of a red giant (A. Reiz). The other two solutions lie rather close to one another, representing stars of more or less normal size (Hayashi). However, when the fraction of the stellar mass in the core increases (due to the progressive nuclear reaction) these two solutions disappear (S. Chandrasekhar), leaving the evolving star in an odd position of 'not knowing what to do'.



Dependence between the pressure at the interface and its radius for the base of the radiative envelope and the surfaces of two isothermal cores. (Schematic drawing)

The situation is represented schematically in the accompanying graph showing three intersections (1, 2, 3) for smaller cores and only one intersection (3′) for larger cores. The disappearance of two intersections for larger cores means physically that it is no longer possible to fulfil the continuity conditions both for temperature and pressure. If we 'force' a solution for some interface-radius a, we find an inversion of pressure and the star will start to collapse. We can, of course, stabilize the model by raising the temperature (and hence the pressure) at all points of the core; but this will produce a non-stationary thermal state, and lead to gradual heating of the inner layers of the hydrogen-containing envelope. The situation is rather analogous to that in an ordinary electric bell, where the clapper can neither stay at the electromagnet nor at the electric contact. It is difficult to predict the behaviour of the model without rather elaborate hydrodynamical calcula-

tions (cf. G. Gamow and C. Longmire); but it is apparent that at this point of evolution the static model must go over into some kind of periodic motion. When the stability conditions are just exceeded, we would expect short-period motion with small amplitudes. As the core grows, both period and amplitude would be expected to become larger and larger. Thus, we have here a picture which may be useful for the explanation of the Kukarkin–Parenago relation, provided we consider different *U*-Geminorum stars as successive evolutionary stages of a single stellar mass. It may, indeed, easily happen that the 'oscillations' described above will result in periodic convectional instabilities. In this case a rapid mixing of cool hydrogen from the envelope with hot helium from the core will result in periodic nuclear explosions of the star. There is also the possibility that similar instabilities may develop in 'swollen-up' solutions of the shell-model. If the resulting central explosions are comparatively weak, they will not show through the thick body of the star and may act as a 'buzzer' mechanism for maintaining regular stellar pulsations.

It is too early to say whether or not the above views will lead to a correct explanation of the dynamical states of ageing stars. The study of the hydrodynamical equations involved in the problem is extremely difficult, and can be done only by means of modern electronic computers. Work in this direction is now being done by the author and his colleagues, A. Carson, G. Keller, C. Longmire, N. Metropolis, L. Peck and R. Richtmeyer, with the hope of having solutions run on a new electronic computer ('Maniac') under construction at the Los Alamos Scientific Laboratory.

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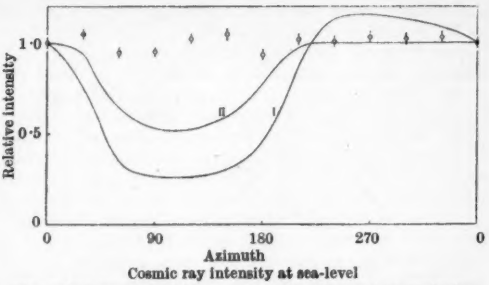
Evidence of Multiple Meson Production

Direct evidence of the production of several mesons by a single primary proton in cosmic rays has been obtained by cloud chambers and photographic plates[1], and indirect evidence by observations of a relatively low average energy of mesons at sea-level[2,3]. Further indirect evidence is furnished by the absence of azimuthal intensity variation obtained as a result of the experiment described here.

Four triple-coincidence counter telescopes, each differing in azimuth by 90°, were used at sea-level, geomagnetic latitude 43·5° S., the middle counter in each telescope having 5 cm. of lead on either side of it. The angle subtended by each telescope was 13° × 3·5°, the larger angle being in the vertical plane, and the zenith angle was 60°. Intensity measurements were made at azimuth intervals of 30°, the average counting-rate being 16·00 per day. From the measured counting-rates, 3·75 counts per day were subtracted, this figure being taken as the shower counting-rate, obtained using a telescope



Cosmic ray intensity at sea-level

Theoretical curves I (single meson production) and II (including meson decay). ○, observed intensities, showing ± standard error

identical with the others except that the middle counter was moved out of line.

From the shadow cone theory[4] the primary cut-off momentum interval explored was calculated to be from 3,600 MeV./*c* at azimuth 270° to 16,000 MeV./*c* at 120°.

The measured intensities, after shower correction, are plotted in the accompanying graph, each point being based on approximately 1,700 counts. Curve I is calculated using a primary momentum spectrum $dN = KP^{-2}dP$, the exact form of which is not important, assuming each primary gives rise to a single meson capable of penetrating to sea-level, and is normalized to unit intensity at 0°, corresponding to an observed corrected value of 12·19 ± 0·38 counts per day. Curve II is drawn taking into account the effect of meson decay. It is clear that an asymmetry is to be expected, which is at variance with the observations, for only one point differs from the mean of 12·25 by more than twice the standard error.

The observed uniform intensity at all azimuths may be explained by assuming that several secondaries are produced by each primary, and that the maximum momentum of a secondary produced by a primary with momentum between 3,600 and 16,000 MeV./*c* is less than the momentum loss in traversing the inclined atmospheric path, that is, less than 4,000 MeV./*c*. If the effect of meson decay is considered, this maximum may be increased slightly, as the probability of a meson of initial momentum 5,000 MeV./*c* penetrating to sea-level is less than 0·1. This conclusion appears to be in agreement with previous results[1–3].

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A Convenient Synthesis of Carbon-labelled Benzene

Several syntheses of benzene and its simple derivatives labelled in the nucleus with isotopic carbon have been described[1–5]. The aluminium-halide catalysed rearrangement of alkyl *cyclo*pentanes to *cyclo*hexanes[6,7] affords an attractive route to benzene and its homologues, and we now present a

preliminary report of an examination of this method as it applies to benzene itself.

*cyclo*Pentane carboxylic acid, prepared by the carbonation of *cyclo*pentyl magnesium chloride at − 30°, was reduced by lithium aluminium hydride[6] to *cyclo*pentyl carbinol (b.p. 159–161°; n_D^{21} 1·4567) in an overall yield of 81 per cent from carbon dioxide. Dehydration of the carbinol over activated alumina at 320° gave a mixture of unsaturated hydrocarbons which after hydrogenation over a nickel catalyst gave a 91 per cent yield of a mixture of methyl *cyclo*pentane and *cyclo*hexane (n_D^{20} 1·4149), shown by infra-red and refractive index measurements to contain approximately 30 per cent *cyclo*hexane. This mixture was treated in a sealed tube at 75° during four hours with water-promoted aluminium chloride[8]; the recovered hydrocarbon (98 per cent; n_D^{20} 1·4228) contained 81·5 per cent *cyclo*hexane. Selective dehydrogenation of the *cyclo*hexane content of this mixture was carried out over a platinum-charcoal catalyst[9] at 350°; in this way recoveries of better than 92 per cent of a product containing about 76 per cent benzene, 20 per cent methyl*cyclo*pentane and 4 per cent *cyclo*hexane were obtained. The platinum–porous pot catalyst described by Berl and Koeber[10] gave satisfactory results with pure *cyclo*hexane, but the presence of even a few per cent of methyl*cyclo*pentane markedly inhibited dehydrogenation of the *cyclo*hexane present. Benzene was isolated from the mixture by formation of the clathrate compound with ammoniacal nickel cyanide solution[11,12]. The recovery of benzene from the above, and similar artificial mixtures, was about 89 per cent, the product having n_D^{20} 1·5011 and melting point 5·5°.

In this manner an overall yield of benzene from carbon dioxide of approximately 45 per cent has been obtained, which may be further improved by carrying out the aluminium chloride catalysed isomerization of methyl*cyclo*pentane at a lower temperature[7] for a longer time, and by recovering and recycling the *cyclo*hexane and methyl*cyclo*pentane which do not react with ammoniacal nickel cyanide. A full account will be published elsewhere.

I am indebted to Mr. R. J. Warne for considerable assistance in the concluding stages of this investigation, and to Mr. J. L. Hales for the infra-red measurements. This communication is published by permission of the director of the Chemical Research Laboratory.

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Action of Dilute Sulphuric Acid on Magnetized Iron

From some observations on the chemical action of dilute sulphuric acid on magnetized iron, it has been stated[1] that, in addition to hydrogen, oxygen is present in considerable quantities, whereas with unmagnetized iron no such phenomenon occurs. We have investigated this further with an apparatus specially designed to exclude atmospheric oxygen and to prevent its subsequent diffusion into the materials. The results obtained with Swedish commercial iron indicated such an effect of the order of magnitude of only 10^{-3} to 10^{-4} by volume[2].

To narrow the limits still further, specimens of spectroscopically pure iron, first heated in an atmosphere of hydrogen and then degassed *in vacuo*, were allowed to react in a magnetized state. The gas analysis, performed with catechol – ferrous sulphate[3], gave colorimetrically a negative result, that is, an oxygen content certainly less than 10^{-6} by volume, which result was obtainable with unmagnetized specimens as well.

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Solidification Curves and Crystal Spacings of Binary Fatty-acid Mixtures

The solidification curves of binary systems formed by adjacent even-numbered saturated fatty acids show, besides a minimum at about 73 mol. per cent of the lower-melting acid, an inflexion at the equimolar composition. To explain this departure from the Roozeboom classification of solid solutions[1], various investigators have assumed the formation of a compound by the two components of the system[2], an obvious assumption in view of the tendency of fatty acids towards association established by Robertson's cryoscopic studies[3]. However, compound formation has not been adequately verified by the results of X-ray measurements of fatty-acid mixtures, and Slagle and Ott[4], having found only one long crystal spacing d_1 instead of two d_1 spacings in mixtures other than equimolar, suggested a continuous series of solid solutions. The peculiar shape of the solidification curves of fatty acids was attributed by them to polymorphism.

During the present investigation, d_2 and d_3 short crystal spacings not reported hitherto for fatty-acid mixtures have been determined in addition to d_1 spacings in C_{12}—C_{14}, C_{14}—C_{16} and C_{16}—C_{18} acid-pairs, using a Philips Geiger X-ray spectrometer. Specimens were prepared by melting the samples on glass and rapid cooling. No changes of spacings due to polymorphism were observed. Single sharp values for d_1 spacings computed from third-order diffraction lines were obtained in each case; but these values

were of no particular interest, being reproducible only to ± 0·5 A. On the other hand, values for d_2 and d_3 spacings, which denote lateral distances between the fatty-acid chains, were reproducible to ± 0·01 A.; and while d_2 remained practically the same for all compositions of any given acid-pair, d_3 showed small but distinct changes. As can be seen from the example of C_{12}—C_{14} acids (cf. table), d_3 spacings of the majority of mixtures are uniformly greater than those of either pure component. However, while the mixture containing 5 per cent myristic acid shows a pronounced increase in d_3 as compared with pure acids, mixtures containing up to 25 per cent lauric acid show none. A mixture of 90 per cent lauric and 10 per cent myristic acid has the same d_3 spacing as a mixture of 70 per cent myristic and 30 per cent lauric acid. C_{14}—C_{16} and C_{16}—C_{18} acid-pairs showed similar although less pronounced changes in d_3 spacings for varying compositions.

Crystal Spacings of Mixtures of Lauric and Myristic Acids

Lauric acid (m.p. 44·1° C.) Weight %	Myristic acid (m.p. 54·2° C.) Weight %	Crystal spacings (in A.) d_1	d_2	d_3
100	0	27·0	4·12	3·73
95	5	27·0	4·14	3·80
90	10	27·0	4·13	3·82
80	20	27·8	4·13	3·84
75	25	28·1	4·14	3·84
65	35	28·4	4·13	3·82
55	45	29·4	4·14	3·84
46·8*	53·2*	29·4	4·13	3·82
40	60	30·1	4·14	3·82
35	65	30·4	4·13	3·82
30	70	30·7	4·14	3·82
25	75	31·1	4·13	3·74
20	80	30·8	4·12	3·74
15	85	30·8	4·14	3·74
10	90	31·1	4·14	3·73
5	95	31·5	4·13	3·74
0	100	31·5	4·12	3·73

* Equimolar mixture.

These changes in d_3 spacings acquire significance when compared with the phase diagram for C_{12}—C_{14} acids determined by Jantzen[5], who, on subjecting mixtures of the above acids to very slow cooling (0·2° C. per 24 hr.) to approach equilibrium, obtained the only available solidus–liquidus curve of a binary fatty-acid system. His diagram, as reproduced and interpreted by Bailey[6], indicates maximum intersolubility in the solid state in mixtures containing up to 20 per cent myristic acid on one side and up to 35 per cent lauric acid on the other, these percentages being, according to Bailey, probably too high. In the remaining range there are partial solid solutions and compound formation. The accompanying table shows that the addition of 10 per cent myristic acid produces the same increase in d_3 spacings as does the addition of 30 per cent lauric acid. It seems justifiable to correlate the above figures with those obtained from Jantzen's diagram, since it can be assumed that maximum intersolubility of two fatty acids coincides with the maximum packing density, which is determined to some extent by d_3 spacings. Both results imply that the longer-chain myristic acid is less soluble in the shorter-chain lauric acid than is lauric in myristic, which is not unexpected.

It appears from Jantzen's diagram that the question of compound formation versus continuous series of solid solutions resolves itself into the problem of determining the areas of various phases existing in the solid state, and we suggest: (*a*) that the boundaries inside which partial solid solutions and compound formation occur are indicated by increased d_3 spacings; (*b*) that an improved technique of measuring short crystal spacings of mixtures of fatty acids may help in defining the above boundaries, not only more conveniently, but perhaps even more accurately than the lengthy procedure of determining solidus–liquidus curves. Solidification curves obtained without achieving equilibrium in the system are of little use in this respect.

We are indebted to Prof. F. J. Llewellyn, of Auckland University College, and to Dr. K. Strzemienski, Soil Bureau, N.Z. Department of Scientific and Industrial Research, for discussion.

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C_{20-22} Unsaturated Acids of Butterfat

Apart from the fact that Bosworth and Sisson[1] established the presence of arachidonic acid in butterfat, there is little, if any, precise information (cf. Bosworth and Brown[2]) regarding the nature of other C_{20-22} unsaturated acids. The purpose of this communication is to record the results of work in progress which support Hilditch's opinion[3] in regard to the C_{20-22} unsaturated acids of butterfat that, "while arachidonic acid may be the chief component, there are probably other polyethenoid (tetra- and pentaene) acids present, possibly of the C_{22} as well as of the C_{20} series".

The samples of butterfat used in the present investigations were obtained through the courtesy of the Dairy Research Institute, Massey Agricultural College. Sample *A*, churned in April 1945, was from a mixed herd at the College, while sample *B*, churned in May 1947, was from the Rangitaiki Plains Dairy Co.

The isolation of the C_{20-22} fractions was achieved by high-vacuum distillation of the methyl esters using a Vigreux column (210 cm. × 6 cm.) for the

Table 1. Composition of the C_{20} Unsaturated Acids of Butterfat
(Results expressed as a percentage of the fraction)

Sample	Conjugated Diene	Conjugated Triene	Conjugated Tetraene	Non-conjugated Monoene	Non-conjugated Diene	Non-conjugated Triene	Non-conjugated Tetraene	Non-conjugated Pentaene
*A*1 (sap. equiv. 338·3, iod. val. 216·5)*	12·3	1·3	0·2	32·3	0·7	18·2	23·9	11·1
*A*2 (sap. equiv. 342·7, iod. val. 178·6)	9·9	1·9	0·2	42·9	—	3·8	18·0	23·3†
*B*1 (sap. equiv. 319·6, iod. val. 157·3)	6·4	2·6	trace	56·4	2·9	7·3	17·5	6·9
*B*2 (sap. equiv. 318·5, iod. val. 228·2)	7·4	3·4	0·1	29·8	4·2	12·5	30·9	11·7

* Constants determined on methyl esters. † Includes also some hexaene acid, *E* (1%, 1 cm.) 375 mμ = 10·5

preliminary concentration and a smaller (240 cm. × 4·5 cm.) column for the final purification. For sample *A*, the methyl esters from the most soluble acids prepared by crystallization from acetone at − 79° C. were used. In the case of sample *B*, the C_{20} concentrate was prepared from the methyl esters of the total fatty acids. The concentrate thus prepared was first freed from saturated acids by crystallization three times from 15 volumes of acetone at − 30° C. After redistillation of the soluble portion, the corresponding acids (*B*1) were crystallized three times from 10 volumes of acetone at − 78° C. to separate the highly unsaturated acids *B*2.

The results given in Table 1 are based on the alkali isomerization technique as described by Beadle and Kraybill[4]. As, however, no value for *E* (1%, 1 cm.) was available for the pure pentaene acids, it was necessary to prepare a pentaene concentrate by chromatographic adsorption on alumina using as a solvent petroleum ether, b.p. 50–60°, containing 1·5 per cent ether. The concentrate thus prepared, to judge from the iodine value of the methyl esters (366·9), contained 57·8 per cent pentaene acids, assuming that tetraene and pentaene acids only were present. From the absorption characteristics of this concentrate after alkali isomerization by the Beadle and Kraybill[4] technique, the absorption characteristics of the pure pentaene acid were calculated by substituting the known values for the tetraene acid as given by these workers (cf. Table 2).

Table 2. Absorption Characteristics of a C_{20} Pentaene Concentrate of Butterfat

	E (1%, 1 cm.) 234 mμ	268 mμ	316 mμ	348 mμ	375 mμ
Before isomerization	42·0	41·5	trace	trace	trace
After isomerization	551·2	453·1	296·0	145·7	trace
Calculated values for pure pentaene acid	448·8	321·7	347·1	252·1	—

Widmer and Holman[5], using for isomerization 23 per cent potassium hydroxide–glycol for 8 min. at 180° C., found by interpolation of the values for diene, triene, tetraene and hexaene acids, a value of *E* (1%, 1 cm.) 348 mμ for the pentaene acid of 300. We have found, however, for our pentaene preparation isomerized by the Widmer and Holman[5] procedure a value of *E* (1%, 1 cm.) 348 mμ of 471, corresponding to a value of *E* (1%, 1 cm.) 348 mμ of 814 for the pure acid. The difference between our high value and the much lower value of Widmer and Holman[5] may be due to the fact that the hexaene standard which they used for interpolation was impure.

The absence of a pure pentaene standard, together with the difficulty of separating the methyl esters of the higher unsaturated acids into fractions containing the same number of carbon atoms, imposes limitations on the results now presented. Nevertheless, general confirmation of the presence of monoene, diene, triene, tetraene and pentaene acids has been obtained by chromatographic adsorption analysis on an alumina column using petroleum ether and petroleum ether–ether mixtures respectively for development and for elution of the chromatogram. Limitations have also been imposed by the quantities of material available. The whole fraction, *B*1 concentrate, for example, amounted to 0·4 per cent of the original butterfat, while the other fractions used formed considerably smaller proportions. Larger quantities of material are now being examined, and it is hoped that further clarification of the nature of the C_{20-22} acids will result.

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Effect of Altitude on the Estimation of 'Crude Fibre'

In the estimation of 'crude fibre' by the Weende method, no provision has been made for the effects of altitude and consequent lowered boiling points of the acid and alkali. The Kabete Laboratories are situated at an altitude of 6,200 ft. and the solutions boil at 94° C.

In order to find the effect of the reduced boiling temperature on the 'crude fibre' estimation, ten samples of material of varying fibre contents were taken to Dar-es-Salaam and 'crude fibre' estimations carried out. Estimations were also made on the same samples by the same worker at Kabete. The results are summarized in the accompanying table, the error involved being calculated in each case as a percentage of the results obtained at sea level.

Sample	Crude fibre in dry matter (per cent) at sea-level	at 6,200 ft.	Percentage error
Maize meal	2·229 ± 0·065	2·705 ± 0·071	21·35
Oats	10·677 ± 0·267	11·846 ± 0·220	10·95
Bran	14·017 ± 0·232	14·727 ± 0·133	5·07
Clover spp.	19·085 ± 0·201	20·232 ± 0·106	6·01
Lucerne	25·980 ± 0·300	27·497 ± 0·102	5·84
Grass			
sample 1	30·455 ± 0·122	32·040 ± 0·094	5·20
,, 2	31·212 ± 0·432	32·897 ± 0·267	5·40
,, 3	32·610 ± 0·227	34·637 ± 0·174	6·22
,, 4	35·372 ± 0·016	37·537 ± 0·389	6·12
Sawdust	64·345 ± 0·200	68·920 ± 0·246	7·11

The extent of the error varies with the type of material, the cereal grains showing greater percentage errors than the other samples examined. There is quite close agreement between the errors found for the legume and grass samples, the average percentage error for the six samples being 5·80 per cent with a standard error of ± 0·17 per cent.

There are three ways of correcting this error: (*a*) by increasing the duration of the boiling; (*b*) by increasing the concentrations of acid and alkali; (*c*) by carrying out the estimation by the standard procedure and applying a correction factor. (*c*) is the most convenient of the three, as (*a*) and (*b*) would involve trial-and-error technique to find the correct increase in duration of boiling or concentration of acid and alkali. It is, also, most liable to error since, as shown above, the percentage error and therefore the correction factor vary for different materials. From the above figures it would seem, however, that the greatest variation occurs in materials with low-fibre content, so that the absolute error involved would be small.

It is probable that the estimation of lignin at high altitudes would be similarly affected, possibly to a

greater extent in view of the longer boiling periods and higher acid concentration involved.

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Positive Bromine Ions ?

In a recent communication[1,2], we described experiments in which bromine migrated towards the cathode from acid HOBr solution across paper-collodion membranes. We interpreted this migration as evidence of 'positive bromine ions' (Br^+ or H_2BrO^+ ions) that were present in these acid solutions. Further experiments revealed, however, that there was a considerable electro-endosmosis across the membranes in the direction of the cathode, and it became necessary to reconsider our results.

We avoided the use of membranes by placing two inverted U-tubes between the beaker containing the HOBr solution and those containing sulphuric acid and acting as electrode compartments. The U-tubes were filled with organic fluids lighter than water and able to react with active bromine. A solution of fluoresceine or carotine in butanol served for this purpose, and in both cases the anodic U-tube changed colour, whereas the cathodic one did not. Pure butanol also reacted with active bromine, and analysis revealed here, too, that migration was directed towards the anode. In each case the bromine accumulated to a greater extent in the anodic U-tube than in a control tube filled with the same reagent and immersed in the HOBr solution but without current passing through it, while the reaction at the cathodic side was less than that in the control tube, being, in fact, imperceptible.

This shows that we were able to detect the presence of OBr^- anions even in our 25 per cent sulphuric acid solution, where, using the new dissociation constant of HOBr as determined by Silov[3], the OBr^- concentration was only 10^{-10}. As no reaction whatever was observed on the cathode side, we may safely assume that the concentration of positive bromine ions, if such do exist, must be less than 10^{-11} in our $N/10$ HOBr solution. We also tried to use such compounds as indicating reactants which do not react with HOBr unless it is acidified, hoping to exclude the reaction of the OBr^- ion. Refractometric measurements with xylene and with ethylbenzoate showed no significant effect, and a green solution of nitrosobenzene in butanol failed to give any colour reaction either. The voltage was about 300 V. D.C. and the current varied according to the conductivity of the organic fluid from a few microamperes to milliamperes. Thus, there is no direct electrochemical evidence for the existence of positive bromine ions.

We happened to prove, however, that fluoresceine migrates towards the anode in solutions more acid than *p*H 3·5, and eosine behaves similarly. We suggest that the ring oxygen atom may be responsible for this effect, acting as centre of an oxonium ion.

A detailed account of our results will appear in *Magyar Kémiai Folyóirat*.

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Budapest. Jan. 16. Gy. Székely

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Conservation of Amino-acid Chromatograms

In filter-paper partition chromatography, the ninhydrin reaction has been used almost exclusively for the identification and quantitative assay of amino-acids. One of the chief disadvantages of the blue pigment formed in this reaction is its rapid fading on filter-paper chromatograms. This makes it difficult to construct permanent or semi-permanent reference maps from which not only the type of amino-acid, but also the approximate quantity of the unknown mixture, can be deduced.

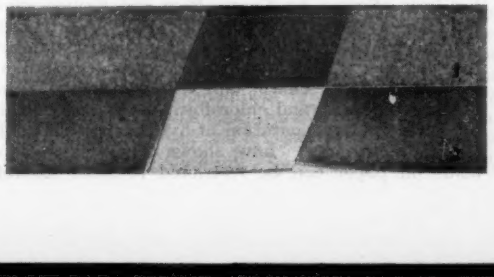
It was found that the blue pigment could be rendered a great deal more stable by coupling it with a metal. This observation was made independently in our two laboratories and has led to a study of the metal derivatives of the blue pigment. All amino-acids form red pigments, except proline and oxyproline which form a yellow metal complex. These findings are summarized in the table. In addition to the metals mentioned in the table, nickel salts also yield red pigments very similar to cadmium.

Amino-acids	$Zn^{\cdot\cdot}$	$Cd^{\cdot\cdot}$	$Co^{\cdot\cdot}$	$Cu^{\cdot\cdot}$
Proline	yellow	yellow	brown	yellow ochre
Oxyproline	grey	yellow	light brown	
Alanine, Glycine, Serine, Threonine	brick red	port wine red	chestnut	salmon
Phenylalanine	red	red ochre	brown	red ochre
Tryptophane	red	orange	brown	red ochre
Other amino-acids	red	port wine red	chestnut	salmon

Apparently the red complex salt is formed from two molecules of diketohydrindylidene-diketohydrindamine (the blue pigment) with one atom of the metal being held between the two nitrogen atoms. Hence it would be correctly described as triketohydrindyliden-2-amino-1-oxy-indenon(3)-metal, for which a structural formula has been suggested elsewhere[1].

In practice, the red complex of the blue pigment is produced by dissolving a salt of one of the metals in methanol or ethanol and spraying each blue spot on the chromatogram with the reagent; on evaporation of the solvent, the corresponding red, reddish-brown or salmon-coloured pigment is formed. The following reagent, which keeps indefinitely, has been found useful: to 1 ml. of a saturated solution of copper nitrate add 0·2 ml. of 10 per cent (v/v) nitric acid and make up to 100 ml. volume with 95 per cent ethanol. This makes approximately a 0·8 per cent solution of copper nitrate at room temperature.

The accompanying photograph illustrates the results which can be obtained. A strip of filter-paper was saturated with a weak solution of alanine, dried, sprayed with 0·1 per cent ninhydrin and heated at 37° C. for 30 min. to develop the blue colour. A centre section of this strip was cut out and put aside, and the remainder was sprayed with the copper reagent. The cut-out section was now replaced and the strip photographed (Fig. 1). The



strip was placed on the work bench in front of the window for one month and then re-photographed on the same film under identical lighting conditions (Fig. 2). The centre section, which had not been treated with copper, had faded completely in this time, whereas the outer portions of the strip show that the red pigment had remained the same.

The red copper pigment, though relatively stable on dry filter-paper where it is out of contact with other ions, is a very unstable salt in aqueous solution. It dissociates into the blue pigment on passing on to the alkaline side of *p*H 7·0, this change being reversible provided the alkalinity does not exceed *p*H 9·0. Ions that compete for copper can also dissociate the complex reversibly; for example, the copper pigment does not form in the presence of tartrate or citrate ions, or in the presence of thiourea which forms a non-ionized copper complex. Free hydrogen ions cause rapid bleaching of the red copper complex.

The optimum conditions under which amino-acid chromatograms can be preserved, therefore, are as follows: (1) the paper must be washed; in practice, the method of Novelle[2] has given satisfactory results; (2) the ninhydrin reagent should not contain a citrate buffer like the reagent proposed by Moore and Stein[3]; (3) after spraying with the copper reagent, the red spot must be momentarily exposed to ammonia vapour in order to neutralize traces of free acid; and (4) the chromatogram should be dipped into a saturated solution of methyl methacrylate polymer 'Perspex' in chloroform to prevent moisture and atmospheric contaminants, such as volatile acids, from acting upon the pigment.

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Application of Buffered Solvent Systems to the Detection of Aromatic Acids by Paper Partition Chromatography

The appearance of aromatic acids during the metabolism of phenylalanine in bacterial cultures has been investigated. In view of the fact that these intermediates are most probably formed in very small amounts and afterwards metabolized rapidly, a sensitive qualitative technique is required for their detection; a chromatographic separation of certain aromatic acids was therefore attempted.

The separation of aromatic hydroxy compounds has been effected by Evans, Parr and Evans[1] using butanol–pyridine mixtures in saturated sodium chloride solution, and Kelemen, Tanos and Halmagyi[2] have separated certain *p*-amino aromatic acids with *n*-butanol. Bray, Thorpe and White[3,4] used benzene–acetic acid–water and chloroform–acetic acid–water mixtures for the separation of hydroxybenzoic acids.

Various workers[5–7] have shown that movement of acids on paper can be restricted to more discrete spots if acid or alkali is added to the developing solvent. Although theoretically either should be applicable in the case of aromatic acids, owing to their low volatility, considerable difficulty was, in fact, observed in the subsequent removal of acetic or hydrochloric acid from the paper. The addition of ammonia or organic bases did not in itself produce very good results, presumably due to the loss of buffering action due to their marked volatility. Accordingly, ammonia/ammonium carbonate buffer solutions (1·5 *N* with respect to each) were employed instead of ammonia solution alone to saturate the *n*-butanol in the mobile phase. This resulted in the production of very small spots with little or no tailing.

No. 4 Whatman Paper Used; Chromatograms run at 15° C.

	R_F values		
	n-Butanol ammonium carbonate buffer	*n*-Butanol ethanol ammonium carbonate buffer	*n*-Butanol benzene ammonium carbonate buffer
Anthranilic acid	0·26	0·41	0·20
p-Aminobenzoic acid	0·09	0·15	0·04
p-Hydroxybenzoic acid	0·10	0·23	0·08
Mandelic acid	0·28	0·45	0·22
Hippuric acid	0·31	0·46	0·23
o-Coumaric acid	0·27	0·42	0·20
Sulphanilic acid	0·11	0·19	0·04
Cinnamic acid	0·62	0·62	0·41
Phenylpropionic acid	0·57	0·67	0·44
Phenylacetic acid	0·44	0·58	0·35
Benzoic acid	0·41	0·58	0·34

In the first column of the accompanying table are given R_F values for a number of aromatic acids developed with *n*-butanol saturated with the ammonia buffer. Similar success in limiting the size of spot has been attained in chromatograms of keto-acids run as the corresponding 2,4 dinitrophenylhydrazones, and the homologous series of dibasic acids from oxalic to suberic.

The separation of certain of the acids under these conditions is not great and additions were made to the *n*-butanol–ammonium carbonate buffer in an attempt either to accelerate the rate of the fast-moving acids or to depress the rate of flow of the slower-moving ones. Ethanol was of considerable use in the former respect (cf. column 2 of table), while benzene was effective in the latter (cf. column 3). The constitution of the two mixtures was as follows: *n*-butanol 40, ethanol 11, buffer 19 (v/v); and *n*-butanol 80, benzene 5, buffer 15 (v/v). The response was, however, insufficient to induce the separation of the lowest two members of the homologous series of arylaliphatic acids.

It was found that short runs (20 cm.) by upward irrigation[8] gave the best results, since longer runs suffered from marked diffusion. Occasional fading of the background to assume the acid colour of the indicator on spraying is probably due to the presence of carbon dioxide from the dissociation of the carbonate buffer during the drying process, and a minimum drying period of 4–5 min. at 150° C. is necessary. There was no variation of R_F value with concentration over the range 0·2–1·2 per cent w/v. Concentrations greater than this gave such elongated spots that it was impossible to determine the R_F, an observation which is in agreement with that of Brown for salts of the aliphatic acids.

Selection of a satisfactory indicator was also investigated. The best results were obtained with buffered solutions of methyl red. A mixture of 5 parts

of 0·1 per cent alcoholic methyl red solution with 10 parts of $M/15$ phosphate buffer solution pH 7·0 gave pink spots on a yellow background. The latter fades slowly to a very pale pink or disappears completely, leaving the spots still distinct. A mixture of equal portions of methyl red and bromo phenol blue (0·1 per cent alcoholic solutions) with twice the volume of buffer gave bright pink spots on a pale grey background, fading overnight to a pale violet. Benzoic and mandelic acids showed up better with this indicator mixture than with any of the other mixtures tried.

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Ferric-ion Catalysed Decomposition of Hydrogen Peroxide and the Polymerization of Acrylonitrile

The question of the mechanism of the iron (III) ion catalysed decomposition of hydrogen peroxide has been discussed in two recent communications[1]. The formation of free radicals initiating the polymerization of monomers during reaction between iron (II) ion and hydrogen peroxide has been demonstrated by Baxendale, Evans and Park[2], and the mechanism of the reaction of iron (II) ion and iron (III) ion with hydrogen peroxide has been discussed by Barb, Baxendale, George and Hargrave[3].

To clarify the question of the formation of free radicals in the iron (III) ion catalysed decomposition of hydrogen peroxide, I used water solutions of acrylonitrile (from the American Cyanamid Co., redistilled before use). The amount of hydrogen peroxide decomposed and that of polymer formed were determined during the course of the reaction. All other conditions remaining unchanged, the velocity of the decomposition of hydrogen peroxide in the presence of acrylonitrile is much slower than without it. The velocity of decomposition depends on the concentration of acrylonitrile. As an example, in a reaction mixture at 25·00 ± 0·05° C. which was 8·00 millimolar in iron (III) nitrate, 0·100 molar in hydrogen peroxide, and contained nitric acid so that the pH of the solution was 1·68 and was 0·40 molar in respect of acrylonitrile, the first-order reaction constant of hydrogen peroxide decomposition was $5·5 \times 10^{-4}$ min.$^{-1}$, while without acrylonitrile the corresponding constant was $3·1 \times 10^{-2}$ min.$^{-1}$. (The reaction constants were calculated analytically using the method of least squares.) The decomposition of the hydrogen peroxide was thus slowed down 56-fold. In the presence of acrylonitrile in the above case, the concentration of hydrogen peroxide was followed for 450 min., at which time about 22 per cent of the original hydrogen peroxide was used up. At the same time, 86 per cent of the monomer originally present was precipitated as an insoluble polymer. The velocity of formation of the polymer, after an initial induction period of about six minutes, during which time the solution remained clear to the eye, goes through a not very pronounced maximum. The maximum occurred between 30 and 40 mm., from the appearance of the heterogeneity in the solution; the rate of the disappearance of the monomer was then $3·7 \times 10^{-3}$ mol. min.$^{-1}$ lit.$^{-1}$. The ratio of disappearing monomer to that of hydrogen peroxide at the above maximum (expressed as molar ratio) is about 70.

At practically the same pH of the solution, but with the concentration of the monomer increased to 1·06 mol. lit.$^{-1}$ and that of hydrogen peroxide decreased to 0·021 mol. lit.$^{-1}$, the constant for the first-order decomposition of hydrogen peroxide was decreased only 17-fold compared with a monomer-free solution. The maximum velocity of monomer disappearance as measured by polymer formation was $2·1 \times 10^{-2}$ mol. min.$^{-1}$ lit.$^{-1}$, and the ratio of disappearing monomer to that of hydrogen peroxide was then about 560. The formation of the polymer proceeds with easily determinable velocity even in the presence of hydrogen peroxide having a concentration of 1·8 millimoles lit.$^{-1}$.

The increasing acidity of the solution decreases the rate of formation of the polymer; it also decreases the rate of decomposition of hydrogen peroxide in the presence of the monomer.

These results extracted from the experimental data can only be interpreted in favour of the chain mechanism of the hydrogen-peroxide decomposition.

Hitherto, the amount of hydrogen peroxide which decomposed in the presence of a monomer with the formation of oxygen has not been determined. The molecular weight of the polyacrylonitrile formed has not been determined. It seems probable that such determination would be possible after polyacrylonitrile is transformed into polyacrylic acid by careful hydrolysis.

A detailed report and analysis of the results will be published in due course.

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Acid Front in Granitization

During the course of field mapping a part of the khondalitic region near Salur (lat. 18° 36′ N., long. 83° 11′ E.) in the Vishakapatnam hill tracts, an interesting contact has been observed between a lens-like band of quartz-biotite-granulite (a member of the khondalites) and a porphyritic granite considered as intrusive[1] into the members of the khondalites in this region. The lens measures about 50 ft. in length, and 10 ft. in width, and appears at first sight as a caught-up xenolith amid the porphyritic granites.

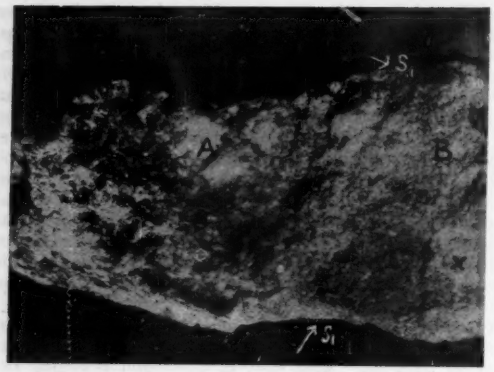

Fig. 1

Careful examination at the contact shows a profound transfusion of quartzo-feldspathic material from the porphyritic granite into the lens along the whole of its length up to a distance of 2 ft. A typical specimen was collected from the contact, and though unfortunately broken into two pieces in the field, it has in no way affected the features exhibited before the mishap.

The whole specimen can be divided into three well-defined zones, *A*, *B* and *C*, as shown in Figs. 1 and 2, which are easily distinguishable from one another to the naked eye by their colour, texture and grain size. Zone *A* belongs to the porphyritic granite, and zones *B* and *C* are those of the lens, adjacent to the granite. Zone *A*, white to greyish-white in colour (sometimes appears black due to streaks of biotite), consists of porphyritic feldspars measuring from two inches to eight inches, embedded in a coarse-grained matrix of quartz, feldspar, garnet and streaks of flaky biotite. Zone *B* is grey in colour, medium- to coarse-grained with quartz, feldspar and relatively tiny flakes of biotite. This zone shows often a tendency to the development of incipient feldspars (marked *X* in Fig. 1). Zone *C* is dark grey to bluish-grey, with fine grains of quartz-feldspar, biotite and grains of garnet.

An interesting feature in the specimen is the recognition of two quartzo-feldspathic screens (S_1 and S_2), consisting entirely of coarse quartz and feldspar grains to the exclusion of biotite and garnet, separating zone *A* from *B* and zone *B* from *C* respectively. The width of the screens varies from 3 mm. at its narrowest to 6 mm. at its widest points. Screen S_1 between zones *A* and *B* sometimes diffuses apparently into a porphyritic feldspar of zone *A*. Moreover, the two screens have slightly diffuse margins towards their preceding zones and clearly defined margins towards their forward zones. Such an occurrence of two distinct quartzo-feldspathic screens approximately parallel to one another precludes the possibility of considering them as chilled margins of the porphyritic granite against the lens, or as reaction rims developed as a consequence of reciprocal reaction between the porphyritic granite and the lens or as segregated veins due to metamorphic differentiation. Transfusion of matter from one solid into another under the influence of heat has been reported from an accidental experiment between two magnesite bricks in a furnace by Adams[2], and hence the development of zones in the lens has to be attributed either to solid diffusion or to transfusion of matter from the porphyritic granite into the lens under the influence of PTX conditions.

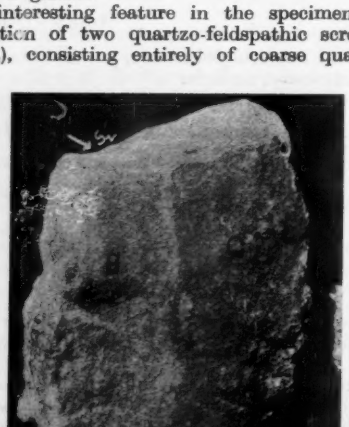

Fig. 2

The existence of "acid and basic fronts in granitization", due to the diffusion of ions of potassium, sodium, aluminium, calcium, magnesium, iron, titanium, phosphorus and silicon through paths of least resistance and obstruction in crystal lattices and along inter-mineral boundaries, has been accepted by the exponents of granitization[3-6]; hence the two quartzo-feldspathic screens may be regarded on the evidence adduced above as 'two acid fronts' advancing as waves either independently or following a basic front in the process of granitization of the lens.

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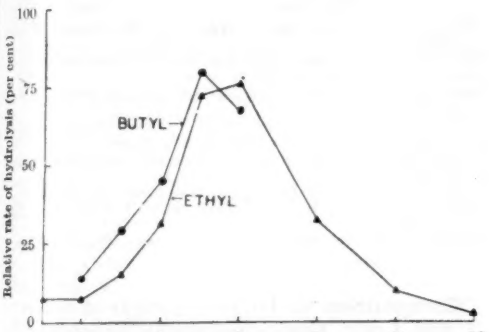
Ali-esterase of Rabbit Polymorphonuclear Leucocytes

Recently, Sturge and Whittaker[1] reported on the relative rates of hydrolysis of a series of straight-chain aliphatic esters by the aliphatic esterase (ali-esterase of Richter and Croft[2]) of horse plasma. With several notable exceptions, acetates were hydrolysed more rapidly than the corresponding propionate or *n*-butyrate (that is, the optimal number of carbon atoms in the *n*-acyl group was usually two) and *n*-butyl esters were hydrolysed more rapidly than the corresponding *n*-propyl or *n*-amyl esters (that is, the optimal number of carbon atoms in the *n*-alkyl group was usually four).

One of the difficulties encountered in studying the substrate specificity of an ali-esterase is that animal tissues contain at least four enzymes, or groups of enzymes, capable of hydrolysing the ester linkage of the simple aliphatic esters, namely, true cholinesterase (specific, *e*-type or aceto-cholinesterase), pseudo-cholinesterase (non-specific, *s*-type or butyro-cholin-

esterase), ali-esterase (common esterase) and lipase. Most tissue extracts, tissue homogenates or sera contain at least three, and may contain all four, of these enzymes, and there is considerable overlapping in their substrate specificity.

Using the soluble ali-esterase preparation obtained from rabbit polymorphonuclear leucocytes (Rossiter and Wong[2]), a study has been made of the relative rates of hydrolysis of a series of straight-chain aliphatic esters similar to that used by Sturge and Whittaker[1]. This enzyme preparation catalyses the hydrolysis of many aliphatic esters; but is inactive towards acetylcholine, acetyl-β-methylcholine, benzoylcholine and triolein. It is thus devoid of true cholinesterase, pseudo-cholinesterase or lipase activity and is a favourable preparation for the study of the substrate specificity of a typical ali-esterase.



Effect of changing the number of carbon atoms in the *n*-acyl group on the relative rate of hydrolysis of a series of ethyl and *n*-butyl esters by the ali-esterase of rabbit polymorphonuclear leucocytes. 100 per cent, rate of hydrolysis of methyl caproate

The accompanying figure shows the effect of increasing the number of carbon atoms in the *n*-acyl group on the relative rates of hydrolysis of a series of ethyl and *n*-butyl esters. Results are expressed as a percentage of the rate of hydrolysis of methyl caproate, which was the most rapidly hydrolysed straight-chain ester. In the two series presented, the most rapidly hydrolysed esters were ethyl *n*-caproate and *n*-butyl *n*-valerate, respectively; that is, the optimal number of carbon atoms in the *n*-acyl group was either five or six. Similar results were obtained with the methyl (peak at caproate), *n*-propyl and *n*-amyl (peak at valerate) esters. Changes in the size of the *n*-alkyl radical had only a slight effect on the rate of hydrolysis, methyl esters usually being the most rapidly hydrolysed. This pattern of specificity obviously differs greatly from that described by Sturge and Whittaker[1] for the horse plasma ali-esterase. The two sets of observations taken together would suggest that there are at least two groups of ali-esterases, each with a characteristic specificity pattern. Sturge and Whittaker[1] mention the possibility that their preparation may contain a second ali-esterase with a different pattern of specificity. The same could well apply to the rabbit polymorphonuclear leucocyte ali-esterase preparation. Limitation of material has precluded any attempts at enzyme purification. No special claims are made for the homogeneity of the preparation other than its freedom from cholinesterase and lipases.

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Renewal of Bone Phosphate in Experimental Hyperparathyroidism

THE mode of action of parathyroid hormone is still obscure. The hormone seems, however, to exert its effect on calcium metabolism partly by a direct action on the bones[1]. Within a few hours profound changes appear in the bones of animals which have been given large doses of parathyroid extract[2]. The bone cells change their appearance and become dedifferentiated, that is, they do not reach full maturity functionally[3]. Concurrently there is a rapid resorption of mineral salts, the resorbed bone being replaced by fibrous tissue.

Experiments, involving the use of radioactive phosphate (to be published in full elsewhere), have shown that the inorganic part of bone consists of different fractions with varying solubility in salt solutions, the fractions having different rates of renewal. The portion which is extractable with saturated ammonium sulphate of *p*H 7·5 has the highest exchange velocity with serum phosphate; the rest of the bone phosphate remains weakly labelled for long periods. Neither of these two fractions is homogeneous, however, each consisting of an unknown number of fractions with different rate of renewal. According to radioautographic and microradiographic investigations[4,5], the largest part of the radioactive phosphate taken up by the skeleton is deposited in the Haversian systems (osteons) with relatively low content of mineral salts, that is, young osteons[5], which thus also contain the portion of mineral salts soluble in saturated ammonium sulphate.

The present communication deals with experiments performed in order to obtain information concerning the age and structure of bone resorbed in chronic hyperparathyroidism. For that reason we have determined the ratio between the ammonium sulphate fraction and the remaining fraction, and the renewal in each of them, in rats submitted to prolonged administration of parathyroid hormone.

Litter-mate male rats, about three months old, and placed on an optimal diet[6] containing 1 per cent calcium and with a Ca/P ratio of 1·0, have been used. Hyperparathyroidism was produced by giving the animals 'Para-thor-mone' (Lilly Co., Indiana) in increasing doses for twenty days; altogether 800 units were given to each animal. The last dose (100 units) was given two hours before administration of radioactive phosphate; 0·3 mC. radioactive phosphate was injected intraperitoneally. After the lapse of the desired time interval, the animals were sacrificed by decapitation. Blood was collected from the carotid arteries and immediately deproteinized in an equal volume of ice-cold 15 per cent trichloracetic acid. The specific activity (that is, number of impulses/μgm. phosphorus) of orthophosphate was

then determined directly[7]. Bone samples (femur and tibia) were removed immediately after death, epiphyseal and diaphyseal bone being separated. The samples were frozen with solid carbon dioxide and pulverized in the frozen state. The powder obtained (about 100 mgm.) was extracted with 2 ml. of saturated ammonium sulphate in the presence of quartz sand for about twenty minutes with the aid of a high-speed rotating glass rod driven by compressed air. After filtering and washings, the residue was extracted with 15 per cent trichloracetic acid.

Table 1. Relative Specific Activity of Phosphate in Two Different Fractions of Mineral Salts in Epiphyseal and Diaphyseal Bone in Normal and Hyperparathyroid Rats

Specific activity of orthophosphate in blood = 100. Phosphate was determined by the method of Fiske and SubbaRow[8]. Radioactivity was measured under a counter after drying an aliquot of the extract on an aluminium dish

Time in hours	1·5		3·0	
Kind of sample	Control animal	Treated animal	Control animal	Treated animal
Epiphyseal bone				
Ammon. sulphate fraction	43	9·9	40	21
Remainder	6·0	1·3	5·4	3·6
Diaphyseal bone				
Ammon. sulphate fraction	15	2·7	22	6·9
Remainder	2·1	0·27	2·1	0·72

Table 1 shows the specific activity of the two fractions of bone salts in relation to that of orthophosphate in the blood. It is clearly demonstrated that, as a consequence of the treatment with high doses of parathyroid hormone, the renewal of phosphate becomes, after the lapse of 1·5 hr., much less both in epiphyseal and diaphyseal bone. The relative lowering of the renewal rate seems to be the same in both fractions. In the experiment of 3-hr. duration, the relative specific activity of the two fractions of bone minerals is in the control animal about the same as after 1·5 hr., which is in agreement with other reports[9,10]. In the treated animals, however, there is a continuous rise in the relative specific activity in the two fractions, both in epiphyseal and diaphyseal bone.

Table 2. Relative Amount of Two Fractions of Phosphate in Epiphyseal and Diaphyseal Bone in Normal and Hyperparathyroid Rats*

Fraction	Epiphyseal bone		Diaphyseal bone	
	Control animal	Treated animal	Control animal	Treated animal
	Per cent	Per cent	Per cent	Per cent
Ammon. sulphate	21	19	16	15
Remainder	79	81	84	85

* Each value represents the mean of two determinations.

Table 2 shows that the ratio between the two fractions of bone salts is the same in control animals as in those treated with parathyroid hormone. These results thus indicate that, in hyperparathyroidism, both fractions are resorbed to the same degree, that is, there is the same destruction in young osteons as in old bone.

Because of the variety of mineral salts resorbed, the hypothesis is advanced that the primary action of parathyroid hormone on bone is more intimately associated with the organic constituent of the bone tissue than with the mineral salts. At the same time the difference in the rate of renewal of phosphate in the skeleton between normal animals and those treated with parathyroid hormone seems to support the view that the rate of renewal is not only dependent upon simple physical conditions such as the solubility of the mineral salts or degree of vascularization; calcification as well as rate of renewal must be the result of specific cell activity, which may be regulated by hormonal control.

A more detailed report will be given elsewhere.

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Composition of Histone prepared from Rat Liver Deoxypentosenucleoprotein

The recent report[1] by Hamer on the amino-acid composition of calf thymus histone prompts us to communicate some corresponding observations on a histone prepared from rat liver deoxypentosenucleoprotein. Nuclei were isolated from briefly homogenized suspensions of perfused rat liver (Sprague-Dawley–Holtzmann strain) and washed four times. A citric acid technique at *p*H 6·1 was employed in the preparation[2]. The nuclei were subjected to differential extraction with sodium chloride, 1·0 *M* salt being used for the extraction of the deoxypentosenucleoprotein and dilution to 0·14 *M* salt for its precipitation. Unlike the preparations described in the literature, these are non-fibrous on precipitation, readily soluble in water, non-viscous in either water or molar sodium chloride solution, and of low molecular weight. The deoxypentosenucleoprotein was dialysed against water and the solution so obtained was lyophilized.

Histone was prepared from such stock preparations of deoxypentosenucleoprotein. 300 mgm. was treated with 0·25 *N* hydrochloric acid at 2°–3° for half an hour. The histone derived from the resultant splitting of the deoxypentosenucleoprotein was salted out by saturation with sodium chloride. The histone was dissolved in water and, after exhaustive dialysis against water, the solution was lyophilized.

When a comparable preparation from calf liver was examined in the analytical ultracentrifuge (Spinco Model *E*) at a concentration of 1 per cent and *p*H 3·8, in water, it showed a single symmetrical boundary throughout the period of sedimentation. Homogeneity was also shown in a similar run (1 per cent solution in 0·2 *M* sodium chloride) at *p*H 4·7.

For determination of the amino-acid composition, a sample of 38·6 mgm. was hydrolysed with 200 parts

RAT LIVER DEOXYPENTOSENUCLEOPROTEIN HISTONE

N content of dry protein = 17·2 per cent. P content of dry protein = 0·04 per cent.

Amino-acid (with no. of analyses in brackets)	(1) N as % total N	(2) Amino-acid (gm.) per 100 gm. protein	(3) Amino-acid residues (gm.) per 100 gm. protein	(4) Molec. wt. calc. from data in (3)	(5) Assumed number of residues	(6) Molec. wt. calc. from data in (4) and (5)
Alanine (2)	7·41	8·11	6·47	1100	16	17,600
Ammonia (3)	5·05	1·05	0·99	1620	11	17,800
Arginine (2)	29·81	15·93	14·35	1090	16	17,400
Aspartic acid (3)	4·30	7·02	6·07	1900	9	17,100
Glutamic acid (2)	5·78	10·44	9·17	1410	12	16,900
Glycine (3)	6·31	5·81	4·42	1290	14	18,100
Histidine (3)	4·64	2·94	2·59	5290	3	15,900
*iso*Leucine (3)	3·54	5·70	4·92	2300	8	18,400
Leucine (3)	6·24	10·08	8·68	1300	14	18,200
Lysine (3)	12·20	11·54	10·12	1260	14	17,600
Methionine (3)	0·88	1·61	1·42	9220	2	18,400
Phenylalanine (5)	1·39	2·83	2·52	5830	3	17,500
Proline (3)	1·91	2·70	2·28	4260	4	17,000
Serine (2)	4·19	5·39	4·47	1970	9	17,700
Threonine (3)	4·42	6·47	5·48	1860	10	18,600
Tyrosine (3)	2·41	5·36	4·84	3370	5	16,900
Valine (3)	4·48	6·43	5·44	1820	10	18,200
Total	104·9		94·3		160	17,600 ± 460

Analytical values on duplicates or triplicates agreed to within 3 per cent of the mean except histidine (± 4), isoleucine (± 5), lysine (± 5), methionine (± 21), proline (± 10) and tyrosine (± 8). Cystine and tryptophan were absent.

of 6 *N* hydrochloric acid twice distilled in glass. Starch column chromatography, collection of samples, and analysis of the eluates were carried out as described by Moore and Stein[3–5]. Two of the samples were run in triplicate and one in duplicate by the use of three starch columns on the fraction collector. The results are shown in the accompanying table.

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Effect of a Single Injection of Carbon Tetrachloride upon the Activity of the Pseudo-cholinesterase in the Liver and Serum of Male and Female Rats

Brauer and Root[1] and Ellis, Sanders and Bodansky[2] produced liver injury in rats by frequent injections of small doses of carbon tetrachloride over a period of six to twelve days. There was a definite fall in the cholinesterase activity of the liver and a somewhat delayed fall in that of the serum; but the continued administration of the poison renders the findings difficult to interpret. If the enzyme in the serum is derived from the liver[1,2], the regeneration of the liver tissue after injury should be accompanied by restoration of the serum and liver cholinesterase to the normal level. Cameron and Karunaratne[3] found in the rat that a large single injection of carbon tetrachloride caused zonal necrosis, centrilobular in distribution, within twenty-four hours, and that recovery was complete in seven to fourteen days. It was therefore decided to follow the serum and liver cholinesterase activity in male and female rats for eleven days after a single subcutaneous injection of 0·25 ml. carbon tetrachloride (B.D.H. Analar)/100 gm. body-weight.

Forty-two black-and-white hooded rats of each sex were divided into groups of seven, and the experimental procedures for sampling and estimating the pseudo-cholinesterase in the liver and in the serum were the same as in an earlier study of the effect of starvation[4]. The mean weights of the male and female rats were 295 gm. and 200 gm., respectively, and they changed little during the experiments. Histological sections of the liver were kindly prepared for us by Dr. A. M. Barrett (Department of Pathology, Cambridge). Within 24 hr., small areas of necrosis had developed in the centres of the liver lobules of most of the animals of both sexes; but by the eleventh day the livers again appeared almost or quite normal.

EFFECT OF A SINGLE SUBCUTANEOUS INJECTION OF 0·25 ml. CARBON TETRACHLORIDE/100 gm. BODY-WEIGHT ON THE PSEUDO-CHOLINESTERASE ACTIVITY OF THE LIVER AND SERUM OF MALE AND FEMALE RATS

Sex	Days after injection	Liver: Weight (gm./100 gm. initial body-weight. ± Stand. dev.)	Liver: Cholinesterase units/gm. liver	Serum: Cholinesterase units/ml. serum
Male	0	3·18 ± 0·22	40	8·3
	1	3·62 ± 0·32	17	6·5
	3	3·42 ± 0·33	20	6·7
	5	3·70 ± 0·32	24	5·9
	7	3·89 ± 0·40	33	7·3
	11	3·43 ± 0·31	35	6·4
Female	0	3·00 ± 0·27	117	32
	1	3·60 ± 0·26	32	29
	3	3·82 ± 0·39	65	22
	5	3·82 ± 0·63	75	21
	7	3·85 ± 0·47	78	18
	11	3·58 ± 0·44	95	36

The unit of cholinesterase is defined as the amount of enzyme which liberated 1 *µl.* carbon dioxide/min. from acetylcholine under standard conditions.

From the accompanying table it will be seen that the cholinesterase activities of the liver and serum of female rats were initially much greater than those of the males. In the females, within 24 hr. after the injection, the liver cholinesterase had dropped to a quarter of its initial value, but by the eleventh day it had risen again almost to its original level. The activity of the serum fell more slowly, and was still falling some days after the activity of the liver had begun to rise; but by the end of the experiment it also had returned to normal. A similar delay in the fall

of the serum cholinesterase was observed during starvation, for whereas the liver cholinesterase dropped rapidly during the first two days, the serum enzyme decreased gradually throughout a six-day fast[4].

In the male rats, carbon tetrachloride caused a much smaller fall in the cholinesterase activity of the liver, followed by recovery almost to the normal level in seven to eleven days, whereas the serum cholinesterase remained within the normal limits. During starvation[4], there was no appreciable change in the cholinesterase activities either of the serum or of the liver.

It appears, therefore, that in the female rat a large fall or rise in the cholinesterase activity of the liver is followed by a corresponding change in that of the serum. The close association between the histological recovery of the liver, and the restoration first of the liver and then of the serum cholinesterase activity to normal values, confirm the hypothesis that the liver is the source of most of, or all, the serum enzyme in the rat. The absence of a definite fall in the serum activity following liver injury in the male rats suggests that either the changes in the activity of the liver after carbon tetrachloride were not sufficiently great to be reflected in the serum, or alternatively that the 'non-labile' liver enzyme[4] is not the source of the small amount of pseudo-cholinesterase in the serum of the male rat.

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Histological Changes in the Epithelium of the Small Intestine during Protein Absorption in the New-born Animal

The absorption, without change, of certain globulins of the colostrum by the new-born animal has been known for many years[1]. Smith[2] has reported that the epithelial cells of the ileum of calves contain feebly staining homogeneous bodies which are present in late intra-uterine life but largely disappear within three days of birth. Other intracellular bodies, apparently protein in nature, have been described in the intestinal epithelium of suckling mice and compared with the meconium corpuscles of the human fœtus[3].

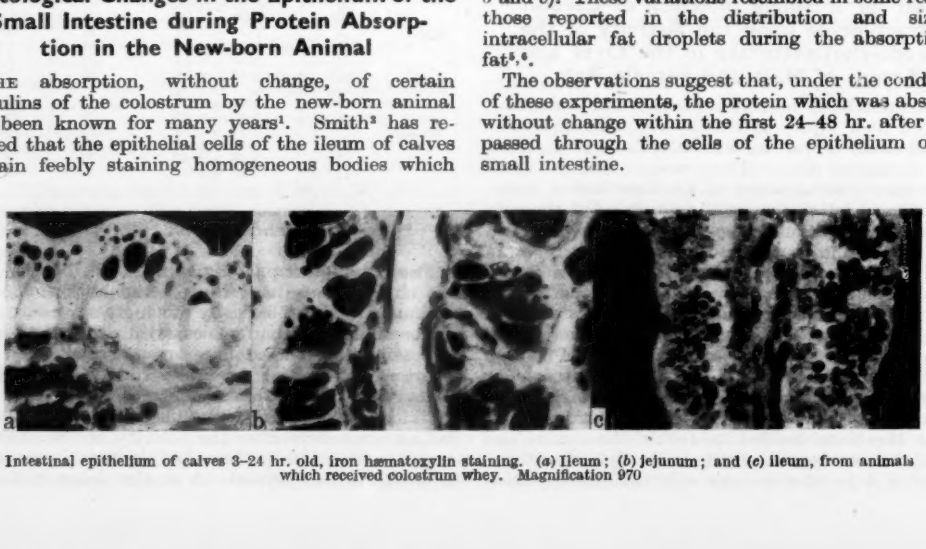
Recent experiments in which the absorption of colostrum globulins was examined in young calves[4] provided material for a study of the changes in the intestinal epithelium under controlled experimental conditions. Colostrum whey, from which the fat had been removed, was introduced through a duodenal cannula. Pieces of the small intestine were removed from the anæsthetized animals and immediately placed in either 10 per cent formol-saline or Susa. Samples were taken from calves 3–24 hr. after birth, which were absorbing the colostrum globulins, and from others of a similar age to which whey had not been administered, and from calves, aged 63–65 hr.

The epithelium of the ileum of calves 9–36 hr. old contained the vesicles described by Smith[2], which stained lightly with toluidine blue.

A striking change was found in the intestinal epithelial cells of calves in which the absorption of protein was taking place. Any whey remaining in the lumen of the gut was coagulated by the fixative and stained as a homogeneous mass with iron hæmatoxylin, azocarmine, eosin or orange *G*. Globules with similar staining properties to the protein of the whey were present in the majority of the intestinal epithelial cells of the jejunum and ileum. In some sections material with the same staining reactions as the whey could be seen in the lacteals. Only a very few droplets of colostrum protein were observed within the cells when the whey was given to calves 63–65 hr. after birth. This is in accordance with the much smaller absorption of globulins found in these older animals.

The size and situation within the cell of the globules of protein varied. In some sections discrete droplets up to 2 μ in diameter were present immediately within the lumen border of the epithelial cells (Fig. *a*). In addition to these, protein material was present in the cytoplasm of the epithelial cells either as one or two large globules, up to 10 μ in diameter, or as a number of smaller drops, 2 μ to about 6 μ in diameter (Figs. *a*, *b* and *c*). These variations resembled in some respects those reported in the distribution and size of intracellular fat droplets during the absorption of fat[5,6].

The observations suggest that, under the conditions of these experiments, the protein which was absorbed without change within the first 24–48 hr. after birth passed through the cells of the epithelium of the small intestine.



Intestinal epithelium of calves 3–24 hr. old, iron hæmatoxylin staining. (*a*) Ileum; (*b*) jejunum; and (*c*) ileum, from animals which received colostrum whey. Magnification 970

We wish to acknowledge the invaluable and skilled assistance of Mr. D. Canwell in the preparation of the histological material.

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Chlorophyll Inhibition and Growth Regulation by Several Tetronic Acid Derivatives

It has been shown that coumarin derivatives are particularly active as inhibitors of germination and root-growth[1–3], and it has been suggested[4] that this action is at least partially due to the unsaturated lactone ring. Since other compounds, hexenolactone[5,6] and protoanemonin[7], containing this unsaturated lactone ring have clearly exhibited some influence on the growth of plants, it seemed interesting to test the simplest compounds having this structure. As an approach to this simple ring, several tetronic acid derivatives were selected which have been synthesized by J. Lecocq[8], to whom we are indebted for the supply of the samples tested.

These compounds were tested on germinating seeds and seedlings of Marketer variety of cucumber (*Cucumis melo*) and White Banner variety of wheat (*Triticum sativum*). The method was to germinate seeds in Petri dishes on filter paper containing the various tetronic acid derivatives at different concentrations. Twenty-five seeds were placed in each dish and 5 ml. of solution was added.

The tetronic acids which were tested included: 3-acetyl-5-methyl-tetronic acid, 3-(α-imino-ethyl)-tetronic acid, 5-5-diphenyl-tetronic acid, 3-(α-methyl-imino-ethyl)-5-phenyl-tetronic acid, 3-diazophenyl-tetronic acid, 3-3′-methylene-5-5-5′-5′-tetra-ethyl-bis-tetronic acid, 3-(α-imino-ethyl)-5-methyl-tetronic acid. A compound of similar configuration, the 2-imino-4-hydroxy-5-5-diphenyl-oxazole was also tested.

The compound producing the most interesting results was 3-(α-imino-ethyl)-5-methyl-tetronic acid. When cucumber seeds were germinated and grown in 100 p.p.m. of this compound, they produced large yellow cotyledons and etiolated hypocotyls. When these seedlings were transplanted into soil and placed on a greenhouse bench, they became white, resembling albino plants, and died after five or six days.

At concentrations greater than 100 p.p.m., not only did cucumber seedlings become chlorotic, but also hypocotyls were markedly inhibited in development. When wheat seeds were allowed to germinate and develop in a solution of 100 p.p.m. or more of 3-(α-imino-ethyl)-5-methyl-tetronic acid, they first germinated and grew normally, but after several days became yellow and then at last partially white. They failed to develop normally and after about two weeks died. When 1 ml. of a solution of 1,000 p.p.m. of 3-(α-imino-ethyl)-5-methyl-tetronic acid was injected into seedlings of red kidney bean stems at a point just below the heart-shaped leaves, the new growth which developed above the primary leaves was in many instances white and stunted. Also, when either of the primary leaves was dipped in a solution containing 1,000 p.p.m. of this compound, the leaf which was dipped became yellow and then gradually white at the margin, and finally about 85 per cent albino with some green colouring still present at the base of the blade.

The action of 2-imino-4-hydroxy-5-5-diphenyl-oxazole was in sharp contrast to that of the preceding compound. When a young primary leaf of red kidney bean was dipped in a solution containing 1,000 p.p.m., the expansion of the leaf was not only almost completely inhibited, but also the leaf became dark green in colour. A solution of 100 p.p.m. also greatly retarded germination of cucumber seeds and completely inhibited seedling development.

The other tetronic acids tested showed less striking effects. For example, responses from 3-(α-imino-ethyl)-tetronic acid were somewhat similar to those from 3-(α-imino-ethyl)-5-methyl-tetronic acid, but to a lesser degree. Preliminary tests with 3-acetyl-5-methyl-tetronic acid suggest that this compound actually stimulates seedling development in wheat.

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[6] Buston, H. W., *et al.*, *Arch. Biochem.*, **22**, 259 (1949).
[7] Thimann, K. V., *Proc. U.S. Nat. Acad. Sci.*, **35**, 2725 (1949).
[8] Lecocq, J., *C.R. Acad. Sci., Paris*, **222**, 183 (1946).

New Hosts of *Phytophthora infestans* in Kenya

The potato has been grown in Kenya for more than half a century, frequently under conditions of temperature and humidity favourable to blight epidemics. It was not, however, until 1941 that blight appeared, and in that year caused widespread destruction of the crop from the eastern escarpment of the Rift Valley, where the first outbreak was observed, to Mt. Kenya[1]. In the following year the disease occurred throughout the Highlands, reaching Tanganyika, Uganda and the Belgian Congo, and is now apparently endemic.

From 1943 blight-immune potatoes from Dr. W. Black have been grown extensively. Those received up to 1948 were immune from blight biotypes *A* and *C* and in the field showed complete immunity. A new biotype *E* which appeared in Tanganyika in 1946 reached Kenya in 1948 and resulted in the breakdown of this resistance, causing much dis-

appointment among farmers. New hybrids immune from biotypes *A*, *B*, *C*, *E* and *F* are now under trial.

During 1950, the foliage of certain woody perennial species of *Solanum* were attacked by blight. In the Highlands of Kenya, these plants abound as weeds of waste places and pastures and as forest undershrubs. No blight had been observed on them hitherto. The disease was first seen on *S. indicum*, growing in forest shade at 6,000 feet near Nairobi. A few weeks later it was collected on leaves of a *Solanum* species, near to *S. pandurœforme*, in forest clearings at the foot of Mt. Kenya some hundred miles to the north-east. A further search discovered *S. incanum*, one of the commonest species, to be generally attacked in the vicinity of the originally observed outbreak on *S. indicum*. (All plants were determined by P. J. Greenway, East African Herbarium.)

Sporangia from *S. incanum* readily infected an unknown variety of potato, from which plants the fungus was transferred to *S. indicum*. Tests by Dr. Black with cultures from this isolation indicated strain *C* as the biotype.

It would appear that a period of approximately ten years elapsed before the resistance of three of the indigenous *Solanum* species to this exotic fungus was broken down.

The occurrence of *P. infestans* on widely distributed perennial host plants may offer new scope for the evolution of yet more aggressive strains of the fungus.

R. M. Nattrass
Moira Ryan

Department of Agriculture,
Kenya.
Feb. 20.

[1] Nattrass, R. M., *E. Afric. Agric. J.*, **7**, 196 (1942).

Changes in Colour Sensitivity of the Eye with Posture

The colour sensitivity of the human eye appears to be influenced, among other factors, by the physical position of the observer.

Normally, when an observer is making colour comparisons, he is in the erect position and with normal vision both eyes exhibit similar colour sensitivities. I have observed, however, that if the observer is in the prone position lying on one side, a gradual difference between the colour response of the two eyes develops. After a few minutes the lower eye becomes markedly red-sensitive compared with the upper eye. If now the observer lies on his back, the two eyes gradually return to equality of colour response. By turning on to the opposite side, the eye formerly red-sensitive will be uppermost and will then gradually develop blue-sensitivity compared with the lower eye.

It occurred to me that this effect, which I have not seen mentioned elsewhere, may be of interest in connexion with theories of colour vision.

J. N. Aldington

Siemens Electric Lamps and Supplies, Ltd.,
Lamp Research Laboratories,
Preston.
March 14.

The Theory of Magnetic Storms and Auroras

In *Nature* of June 16, in a communication on the theory of magnetic storms and auroras, Prof. H. Alfvén emphasizes the need for the theorist to test his work by experiment. He and his colleagues have striven to follow this laudable maxim, which was also urged in his book[1], for example, on p. 37 regarding cosmic discharges, and on p. 78 regarding magneto-hydrodynamic waves (and a note added in proof records the success of S. Lundquist in experimentally demonstrating them). He gave (pp. 39–41) the scale relations between various physical magnitudes involved in laboratory experiments for illustrating large-scale natural phenomena, and these he discussed also (pp. 201–203) in relation to Malmfors's experiment intended to illustrate magnetic storm and auroral theory.

The difficulty is that it may be beyond present experimental powers to fulfil these scale relations in the laboratory—and Prof. Alfvén remarks (p. 201) that this is so regarding the magnetic field in Malmfors's experiment. I have myself recently proposed[2] another experiment to illustrate magnetic storm theory; the fulfilment of the scale relations involved will certainly be difficult, though apparently not impossible. Not having at my disposal experimental skill or facilities, I should much welcome the execution of the experiment by Prof. Alfvén and his colleagues.

Failing such experiments, a purely theoretical treatment, as Prof. Alfvén remarks (p. 37), though "certainly very precarious", is "still, in many cases, the only way of attack". Prof. Ferraro and I, in our work on magnetic storms[3], have often mentioned our consciousness of the precarious nature of such work, and Prof. Alfvén, in his summary and discussion[1] of his own theory[4], likewise very properly makes many reservations as to the proof of his conclusions and the need for the extension of his analytical treatment.

A theorist in such a field must select what he considers the initial bases for the theory, and then develop it from these premises as accurately as possible; mathematical difficulties may force him to stop his chain of deductions without having taken it as far as he would like, and also to leave some of the links weaker than he would wish. The choice of the initial bases may be partly a matter of dispute, and so may be the accuracy of the chain of reasoning from them.

Prof. Ferraro and I will welcome the publication of the objections to our theory that Prof. Alfvén believes are fatal to it, so that if they are invalid we may rebut them, or if valid, re-direct our efforts.

Prof. Cowling[5] has criticized the accuracy of the deductions made by Prof. Alfvén from his initial premises, and his criticisms have not yet received a satisfactory answer, though they are referred to in "Cosmical Electrodynamics", p. 200.

But the subject is far too intricate to be suitable for its details to be discussed in the correspondence columns of *Nature*.

Sydney Chapman

Queen's College,
Oxford.
June 28.

[1] Alfvén, H., "Cosmical Electrodynamics" (Clarendon Press, Oxford, 1950).
[2] Chapman, S., *J. Terr. and Atmos. Phys.*, **1**, 189 (1951).
[3] Chapman, S., and Ferraro, V., *Terr. Mag. and Atmos. Elec.*, **36**, 77, 171, 186 (1931); **37**, 147, 421 (1932); **38**, 79 (1933); **45**, 245 (1940); **46**, 1 (1941).
[4] Alfvén, H., *Kungl. Sv. Vet. Akad. Handl.*, (3), **18**, Nos. 3 and 9 (1939, 1940).
[5] Cowling, T. G., *Terr. Mag. and Atmos. Elec.*, **47**, 209 (1942).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, July 16

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 2.45 p.m.—Dr. F. Sherwood Taylor: "The History of Science, 1851–1951".*

Monday, July 16—Saturday, July 21

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (at the College of Aeronautics, Cranfield, Bedford).—Conference on "Automatic Control".

Tuesday, July 17

INSTITUTION OF CHEMICAL ENGINEERS (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10 a.m.—Conference on "Mixing and Agitation in Liquid Media".

FAUNA PRESERVATION SOCIETY (at the Zoological Society of London, Regent's Park, London, N.W.8), at 4.15 p.m.—Mr. F. W. Champion: "Tropical Forests and Wild Life Conservation".

Wednesday, July 18

ROYAL SANITARY INSTITUTE (at 90 Buckingham Palace Road, London, S.W.1), at 11 a.m.—Conference on the Report of the Catering Trade Working Party on "Hygiene in Catering Establishments".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Sir Harold Scott, K.C.M.G.: "Some British Contributions to Tropical Medicine".

ROYAL METEOROLOGICAL SOCIETY (at East Malling Research Station, East Malling, Maidstone).—Summer Meeting.

Thursday, July 19

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. H. E. Shortt, F.R.S.: "The Life Cycle of the Malaria Parasite".

Friday, July 20

BIOMETRIC SOCIETY, BRITISH REGION (at the National Institute for Research in Dairying, Shinfield, Reading), at 11.30 a.m.—Tenth Meeting.

Saturday, July 21

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, The University, Sheffield), at 10.30 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

JUNIOR ASSISTANT PHYSICIST, mainly in connexion with radiotherapy—The Secretary, University College Hospital, Gower Street, London, W.C.1 (July 20).

ASSISTANT LECTURER (Grade A) IN PHYSICS—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (July 21).

ASSISTANT WORKS CHEMIST (with a sound knowledge of the control of gas manufacture, and experienced in carrying out all the usual gas works tests)—The Divisional Manager, West Midlands Gas Board, Walsall and District Division, Walsall Factory Estate, Tame Bridge, West Bromwich Road, Walsall, quoting Ref. N. (July 21).

ASSISTANTS (Grade B) IN MATHEMATICS (knowledge and interest in statistics would be an asset), BIOLOGY (degree including zoology and botany with honours in one of these subjects), and CHEMISTRY (2 posts, *a*, research or industrial experience and some knowledge of biological subjects would be an advantage, *b*, to teach inorganic chemistry up to B.Sc. Special and A.R.I.C. standard and to assist in general chemistry up to B.Sc. General level)—The Principal, Derby Technical College, Normanton Road, Derby (July 21).

CHEMIST in the Executive's Laboratory Service, to be in immediate day-to-day charge of a power station laboratory in the N.W. or S.W. area of London—The Staff Officer (F/EV.180), London Transport Executive, 55 Broadway, London, S.W.1 (July 21).

GRADUATE with biological training, for work on soil bacteriology—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 21).

GRADUATES IN CHEMISTRY or PHYSICS for two Bursaries, to do research on flame propagation in gases—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7 (July 21).

PRINCIPAL OF THE WEDNESBURY COUNTY TECHNICAL COLLEGE—The Director of Education, Department F.E., County Education Offices, Stafford (July 21).

ASSISTANT LECTURER IN AGRICULTURAL ECONOMICS—The Registrar, The University, Leeds 2 (July 24).

LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY, and a LECTURER IN ORGANIC CHEMISTRY—The Secretary and Registrar, University College of North Wales, Bangor (July 24).

PROFESSOR OF NAVAL ARCHITECTURE AND MARINE ENGINEERING, a PROFESSOR OF POWER STATIONS (Mechanical), and a PROFESSOR OF STRENGTH OF MATERIALS AND SANITARY ENGINEERING, at Farouk I University, Alexandria—The Director-General, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (July 25).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree, preferably in engineering, and some industrial and research experience) in the Mechanical Engineering Research Organization of the Department of Scientific and Industrial Research, to develop and initiate research into mechanisms for application to mechanical engineering problems—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4041/51 (July 26).

LECTURER IN ENGINEERING—The Secretary, The University, Aberdeen (July 27).

COMPUTER (Scientific Technologist II) at headquarters Scientific Department (Scientific Control)—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/351 (July 28).

EXPERT DESIGNING ENGINEER under the Government of India, in India, to be responsible to the Chairman, Central Waterpower, Irrigation and Navigation Commission, for the mechanical and electrical design of such transmission systems as will be required for grid supply connecting super-hydro power stations and long-distance power transmission projects—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.280/51A.O. (July 28).

MECHANICAL ENGINEERS (Scientific Officer grade) at the Ministry of Supply headquarters in London, to originate and supervise research associated with mechanical engineering problems in the aero-engine industry and to represent the Ministry in committee work—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.340/51A (July 28).

MECHANICAL ENGINEERS (Scientific Officer grade) at the Royal Aircraft Establishment, for research into the more fundamental aspects of the development of aircraft hydraulics, pneumatic and oxygen systems, involving problems of gas and liquid flow, control systems and storage—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.354/51A (July 28).

SENIOR LECTURER IN ANTHROPOLOGY at the Australian School of Pacific Administration, Mosman, Sydney, and an ANTHROPOLOGIST (male) in the Public Service of Papua and New Guinea—The Official Secretary, Australian High Commissioner's Office, Strand, London, W.C.2, quoting 'Department of Territories, Canberra' (July 28).

TEMPORARY ASSISTANT TECHNICAL EXAMINING OFFICER (male) in the Victualling Department of the Admiralty—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.60/51A (July 28).

ASSISTANT IN THE DEPARTMENT OF BOTANY, University College, Dundee—The Secretary, The University, St. Andrews (July 31).

CHIEF AGRICULTURAL ECONOMIST (with a specialized degree in agricultural economics, and practical experience in the marketing of agricultural products and in investigations dealing with the costs of production of these products) in the Department of Agriculture and Lands, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (July 31).

DEMONSTRATOR IN GEOGRAPHY—The Secretary, The University, 38 North Bailey, Durham (July 31).

ENGINEERS (Principal Scientific Officer grade) at the London headquarters of the Ministry of Supply: (Ref. C.355/51A) to take charge of a section responsible for initiation and co-ordination of research and development work on aircraft pressure cabins and associated problems and equipments; (Ref. C.356/51A) to control a section responsible for co-ordinating investigations with mechanical engineering problems in connexion with aircraft development—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (July 31).

JUNIOR PROFESSIONAL OFFICERS (2) IN THE ENTOMOLOGICAL BRANCH, Department of Agriculture, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (July 31).

LECTURER IN PURE MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (July 31).

LECTURER OR ASSISTANT LECTURER IN AGRICULTURAL ECONOMICS at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 31).

METALLURGIST (Chemist III grade) for the Ministry of Supply in Middlesex, to take charge of metallographic laboratories—work covers metallic materials of all kinds used in aircraft, with joining, corrosion preventive and other processes applied to metals—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.440/51A (July 31).

PHYSICISTS and PHYSICAL CHEMISTS (Experimental Officer grade) at a Ministry of Supply research and development establishment near London, to operate an electron microscope and to assist in X-ray crystallographic work—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.180/51A (July 31).

RESEARCH FELLOW IN ANTHROPOLOGY at the West African Institute of Social and Economic Research, University College, Ibadan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 31).

SCIENTIFIC ASSISTANT (university graduate in science or agriculture, preferably with special training in nutrition and/or knowledge of foreign languages)—The Director, Rowett Research Institute, Bucksburn, Aberdeenshire (July 31).

SENIOR PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in some branch of science or engineering, or an equivalent qualification, and good experience in research is essential) in the Building Operations Research Unit of the Building Research Station (Department of Scientific and Industrial Research)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4042/51 (August 2).

CHAIR OF PHYSICS in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth 5 Gordon Square, London, W.C.1 (August 4).

GRADUATE IN PHYSICS (with a bias towards engineering) to undertake research work in the unexplored field of glasshouse heating and ventilation—The Head of the Garden Research Department, John Innes Horticultural Institution, Bayfordbury, Hertford (August 4).

RESEARCH OFFICER (Biologist), DIVISION OF FISHERIES, to take part in the research programme on pearl-shell culture at Thursday Island—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3282 (August 4).

CHEMISTS (Principal Scientific Officer or Senior Scientific Officer grade) at the Atomic Energy Research Establishment, Harwell, for work on the electro-magnetic method of separation of stable isotopes—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4045/51 (August 8).

MECHANICAL ENGINEER (Principal Scientific Officer grade) with considerable design experience, to study and to solve the special problems connected with the design of modern radar aerials and their associated scanning and rotating mechanics, an ENGINEER (Principal Scientific Officer grade) with wide experience in, and complete responsibility for, the successful engineering of complex projects involving many different specialist component parts both electrical and mechanical, an ELECTRONICS ENGINEER (Principal Scientific Officer grade) with outstanding ability in precision designs associated with complex electronic equipment, an ENGINEER (Principal Scientific Officer grade) with high-grade experience of the theory, design and utilization of servo-mechanisms, at an Admiralty establishment in the south of England; MECHANICAL ENGINEERS (Principal Scientific Officer grade) with considerable experience in the design of intricate mechanisms, at an Admiralty establishment in the Home Counties; PHYSICIST or ELECTRONICS ENGINEER (Senior Scientific Officer or Principal Scientific Officer grade) with an excellent theoretical understanding and practical experience of, and responsibility for, the design and development of electronic circuits, especially in the high and medium frequency bands, at an Admiralty establishment in the Home Counties; STRUCTURAL ENGINEER with a first- or second-class honours degree in Engineering, or a MATHEMATICIAN with an honours degree in Mathematics (Principal Scientific Officer grade) to supervise the work of applied mathematicians and engineers in the Structural Mechanics Division, at an Admiralty establishment at Rosyth—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4043/51 (August 9).

ASSISTANT IN THE STATISTICS SECTION, for work on problems of tree variation and measurement—The Secretary, East Malling Research Station, Maidstone, Kent (August 11).

LECTURER IN PHYSICS (preferably in Experimental Physics) at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (August 15).

SENIOR SCIENTIFIC OFFICERS (with a first- or second-class honours degree in botany, and well qualified in systematic botany), for research work in the Herbarium or Laboratories, supervision of staff, the identification of plants and plant products and the control of Laboratory equipment, at the Royal Botanic Gardens, Edinburgh—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4046/51 (August 16).

SENIOR LECTURER IN FLUID MECHANICS AND HYDRAULICS, and a LECTURER IN CIVIL ENGINEERING, at Canterbury University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 20).

LECTURER IN GEOGRAPHY—The Secretary, The University, 36 North Bailey, Durham (August 31).

CHAIR OF ANATOMY in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 1).

RESEARCH ASSISTANTSHIP IN INDUSTRIAL RELATIONS—The Registrar, University College of South Wales, Cathays Park, Cardiff (September 10).

ASSISTANT CIVIL ENGINEERS in the Department of Drainage and Irrigation, Malaya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27329/24.

ASSISTANT ENGINEER with power plant experience (and experience in the running and maintenance of diesel-driven A.C. generators, the upkeep of A.C. motors, switchgear and cables) to the Sudan Gezira Board—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Sudan Gezira Board, Power Plant 4/292'.

ASSISTANT LECTURER AND DEMONSTRATOR (with a sound scientific knowledge; a knowledge of leather manufacture would be an advantage)—The Principal, Leathersellers' Technical College, 176 Tower Bridge Road, London, S.E.1.

ASSISTANT LECTURER (temporary) IN PHILOSOPHY—The Registrar, University College, Singleton Park, Swansea.

CHEMICAL ENGINEER or CHEMIST with production experience, for oil plant at Wick, north Scotland—The Herring Industry Board, 1 Glenfinlas Street, Edinburgh 3.

DEPARTMENTAL ASSISTANT (university graduate, preferably with special qualifications in agricultural chemistry) IN AGRICULTURAL CHEMISTRY, and a DEPARTMENTAL ASSISTANT IN POULTRY HUSBANDRY, at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

DIRECTOR (Senior Principal Scientific Officer grade) OF THE WEST AFRICAN BUILDING RESEARCH ORGANISATION—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

EXECUTIVE ENGINEER IN THE PUBLIC WORKS DEPARTMENT, British Honduras—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/138.

HONOURS GRADUATE (Scientific Officer grade) for research on methods of microbiological assay of vitamins and amino-acids—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

LECTURER (university graduate with an honours degree in engineering or physics) IN REFRIGERATION, and a LECTURER (with a degree in mechanical engineering and some practical experience of fan applic tion) IN FAN ENGINEERING—The Clerk to the Governors, Nation College for Heating, Ventilating, Refrigeration and Fan Engineerin Borough Polytechnic, Borough Road, London, S.E.1.

LECTURER IN INORGANIC CHEMISTRY (including spectrochemic analysis), a LECTURER IN APPLIED MATHEMATICS, a LECTURER PHYSICS, and a LECTURER IN ZOOLOGY—The Principal, Sir John C College, Jewry Street, London, E.C.3.

LECTURER IN POULTRY SCIENCE—The Bursar, Harper Adam Agricultural College, Newport, Shropshire.

LECTURER or Grade B ASSISTANT IN PHYSICS—The Registra Medway Technical College, Gardiner Street, Gillingham, Kent.

MATHEMATICIAN or MATHEMATICAL PHYSICIST (with a good honou degree and, preferably, some knowledge of the theory of elasticit for research in applied mechanics—The Personnel Officer, British Iro and Steel Research Association, 11 Park Lane, London, W.1.

MECHANICAL AND ELECTRICAL ENGINEER by the Directorate General of Municipalities, Iraq—The Crown Agents for the Colonie 4 Millbank, London, S.W.1, quoting M.24694.B.

MECHANICAL ENGINEERS (Tractors) in the Department of Agr culture, Sudan—The Sudan Agent in London, Wellington Hous Buckingham Gate, London, S.W.1, endorsed 'Mechanical Engine (Tractors) 4/4'.

PHYSICIST or ENGINEER (university degree in physics or mechanic engineering with mathematics subsidiary essential) to join a researc team investigating deformation of metal, particularly the rollin process—The Personnel Officer, British Iron and Steel Researc Association, 11 Park Lane, London, W.1, endorsed 'Rolling'.

POWER STATION CHEMIST (with a University degree in chemistry or an equivalent qualification) by the Central Electricity Board Federation of Malaya—The Crown Agents for the Colonies, 4 Mil bank, London, S.W.1, quoting M.28340.B.

RESEARCH FELLOWSHIP established by the Nottinghamshire Counc of the British Empire Cancer Campaign—The Registrar, The Uni versity, Nottingham.

RESEARCH STUDENTSHIP for work on oxides in weld metal—Th Head of the Department of Applied Chemistry, Northampton Poly technic, St. John Street, London, E.C.1.

SENIOR EXPERIMENTAL and ASSISTANT EXPERIMENTAL OFFICER to undertake and assist with experimental work involving a wid range of chemical and physical atomic energy development problems and a SENIOR EXPERIMENTAL OFFICER to design and assemble specia electronic equipment for research groups working on atomic energ development problems, in the Research and Development Branc (Applied Research), of the Division of Atomic Energy (Production) at Windscale Works, Sellafield—The Ministry of Supply, Division o Atomic Energy (Production), Risley, Warrington, Lancs (stating pos applied for).

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 865, Vol. 243: Large Elastic Deformations of Isotropic Materials, 7, Experiments on the Deformation of Rubber, by R. S. Rivlin and D. W. Saunders; 8, Strain Distribution around a Hole in a Sheet, by R. S. Rivlin and A. G. Thomas. Pp. 251–298. (London: Cambridge University Press, 1951.) 11*s*. [254

Cambridge University Educational Film Council Fourth Report, February 1951. Pp. 8. (Cambridge: The University, 1951.) [254

British Non-Ferrous Metals Research Association. Thirty-first Annual Report. Pp. 64. (London: British Non-Ferrous Metals Research Association, 1951.) [254

Report of the Rugby School Natural History Society for the Year 1950. (Eighty-fourth issue.) Pp. 55. (Rugby: George Over, Ltd., 1951.) [264

Registrar-General's Statistical Review of England and Wales for the Six Years 1940–1945. Text, Vol. 2, Civil. Pp. v+234. (London: H.M. Stationery Office, 1951.) 5*s*. net. [304

Other Countries

Bulletin of the Bingham Oceanographic Collection. Vol. 13, Article 2: Studies on the Marine Resources of Southern New England, 8: The Biology of the Longhorn Sculpin, *Myoxocephalus octodecimspinosus*, with a Discussion of the Southern New England 'Trash' Fishery. By James E. Morrow, Jr. Pp. 89. (New Haven, Conn.: Peabody Museum of Natural History, 1951.) 1.35 dollars. [244

Fiskeridirektoratets Skrifter, Serie Havundersøkelser. Vol. 9, No. 12: Sprat from Norwegian Waters, an Analysis of Vertebrate Counts. By Gunnar Dannevig. Pp. 22. Vol. 9, No. 13: The Whirling Vessel, an Apparatus for the Fractioning of Plankton Samples. By Kristian Fredrik Wiborg. Pp. 16. (Bergen: A/s John Griegs Boktrykkeri, 1951.) [244

Scientific Reports of the Indian Agricultural Research Institute, New Delhi, for the Year 1947–1948. Pp. iv+182. (New Delhi: Indian Agricultural Research Institute, n.d.) 4.12 rupees; 7*s*. 6*d*. [244

Compania de Diamantes de Angola. Publicacoes Culturais No. 10: Museu do Dundo. Subsidios para o estudo da biologia na Lunda. Estudos Diversos, 3: Semiaquatic Heteroptera collected in Lunda, North-East Angola (Portuguese West Africa) by Dr. A. de Barros Machado in 1946–1949, by Ludvik Hoberlandt; Chiroptera from Dundo, Lunda, North-Eastern Angola, by Colin Campbell Sanborn; On Diplopoda of North-East Angola, by Ralph V. Chamberlin; On Chilopoda collected in North-East Angola by Dr. A. de Barros Machado, by Ralph V. Chamberlin. Pp. 112. (Lisboa: Companhia de Diamantes de Angola, 1951.) [244

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 243: A Soil, Land-Use, and Erosion Survey of parts of the Counties of Moira and Delatite, Victoria. By R. G. Downes. Pp. 89+6 plates. (Melbourne: Government Printer, 1949.) [254